# SCIENCE ABSTRACTS

## Section A.—PHYSICS.

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### FEBRUARY 1921.

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## GENERAL PHYSICS.

**188.** *An Electrical Hot-wire Inclinometer.* **J. S. G. Thomas.** (Phys. Soc., Proc. 32. pp. 291–312; Disc., 312–314, Aug., 1920.)—The hot-wire inclinometer consists essentially of two fine Pt wires (diam. about 0·1 mm.) mounted parallel to one another in a closed chamber at a distance apart equal to about 1 mm. A constant current of from 0·4 to 1·5 amps. (according to the sensitivity desired) is maintained in the wires, which constitute two of the arms of a Wheatstone bridge arranged so that the bridge is balanced in the zero position of the inclinometer. If desired, the bridge may be constituted of two pairs of heated wires as above. The inclinometer wires, in the zero position, may be either vertical or horizontal or inclined at any angle to the horizontal. The indications of the instrument are dependent upon the relative heating or cooling effects experienced by the respective wires when the orientation of the wires with regard to a horizontal plane is altered. The galvanometer deflection occurring with alteration in such orientation serves to indicate the inclination of a definitive radius vector to the horizontal, and calibration curves are given for the cases where the axis of rotation is horizontal, and (*a*) in the plane of the wires and parallel to the wires, and (*b*) at right angles to the plane of the wires. The characteristics of the calibration curves are discussed, and curves are given showing how the resistances of the respective wires depend upon the orientation of the wires with regard to the horizontal plane referred to. Attention is directed to the finite width of the column of heated gas ascending from the wires, and an empirical formula is deduced expressing the maximum deflection as a function of the bridge current employed. AUTHOR.

**189.** *Detection of Form Change by Photographic Means.* **M. H. Stillman.** (Bureau of Standards, Bull. 16. pp. 437–448 [Sci. Papers, No. 392], 1920.)—Describes the application of photography to the detection of small changes in a complicated group of objects. A photograph is taken of the group before and after a change is suspected to have taken place. From the negative of one photograph a positive is made, and this is superposed on the other negative so as to bring them into register, and the combination is viewed against a source of light. If the photographs have been made on similar plates and from nearly the same position with similar conditions of lighting, those parts of the combination which correspond to the unchanged portion will appear as a field of practically uniform density, while a change in the group is shown up by a considerable departure from uniformity. Photographs are reproduced in the paper to show the application of the method. The various precautions to be observed, and the conditions necessary for obtaining the most favourable results, are dealt with in detail. J. W. T. W.

**190.** *Adjustment of Parabolic and Linear Curves to Observations taken at Equal Intervals of the Independent Variable.* **H. M. Roeser.** (Bureau of Standards, Bull. 16. pp. 363–375 [Sci. Papers, No. 388], 1920.)—Least-square reductions of observations taken, at equal intervals, of the independent variable that follow approximately a parabolic or linear law frequently occur in physics and engineering practice. Makeshift devices are often employed to avoid the arithmetical work of determining the constants of curves which properly represent such data. In this paper the ordinary least-square formulæ are subjected to mathematical treatment, and rigorous solutions are evolved which require an ultimate minimum of arithmetical work. A table is given from which a large portion of the solutions can be written down from a mere inspection of the observations. Application of the solutions is made to typical problems, and an absolute check with the ordinary least-square solutions is given. A. W.

**191.** *On the Physical Assumptions of the Calculus of Probabilities.* **H. Reichenbach.** (Zeits f. Physik, 2. 2. pp. 150–171, 1920.)—Section 1 deals with the axioms. The physical problem of the probability calculus differs from the mathematical in that while mathematics is developed from a system of hypotheses based on arbitrary and undemonstrable definitions, physics on the other hand is based on such of the above definitions as conform to reality. Section 2 considers Poincaré's hypothesis and reduction of the probability factors to a probability function; Section 3 discusses the generalisation of the Poincaré hypothesis. Section 4 describes a special form of probability function and a second species of the transition limit. In Section 5 Poincaré's hypothesis is extended to several variables and deals with the multiplication theorem of the probability factors. Section 6 discusses the connection between axioms I and II and several of the probability functions derived from II. Section 7 deals with the multiplication theorem of the probability functions. Section 8 considers the cube problem as a type for a generalised mechanism. Section 9 investigates the flattening of the probability curve by increase of the rotation velocity. In Section 10, application of the hypotheses is made to the last decimals of a physical magnitude. The paper is mathematical throughout. H. H. Ho.

**192.** *Internal Friction of Quartz.* **C. E. Guye and A. Morein.** (Arch. des Sciences, 2. pp. 351–371, Sept.–Oct., 1920.)—Describes the method used and results of experiments on the internal friction of quartz threads at high temperatures. It is found that the relation between friction and temperature depends on the diam. of the thread and, in fact, the structure of a quartz thread is a function of the diameter. The results are comparable with those obtained by Guye and Vassileff [see Abs. 1185 (1914)] for Jena glass threads. J. W. T. W.

**193.** *An Examination of Searle's Method for Determining the Viscosity of very Viscous Liquids.* **K. Molin.** (Cambridge Phil. Soc., Proc. 20. pp. 23–34, Sept., 1920.)—A review of the methods for the determination of the coefficient of internal friction in very viscous liquids will be found in Reiger [see Abs. 1036 (1906)]. Among these an examination of Searle's method is the object of the present paper, a method which consists in causing a vertical cylinder to rotate within a coaxial cylinder containing liquid, and in determining the angular velocity of the inner cylinder for a known value of the driving couple, the latter being produced by the weights of two loads acting on a drum by means of two threads. Searle's viscometer was used and treacle employed as the highly viscous liquid. Elaborate arrangements are described for ensuring temperature regulation. The formula given by Searle for the viscosity $\eta$ is, $\eta = \mathrm{C(MT}/l)$, where T is the time of one revolution of the cylinder, M the mass of each of the two loads, $l$ the length of the inner cylinder immersed in the liquid, and C an apparatus constant. Owing to the conditions which obtain at the bottom surface of the movable cylinder, the formula was modified by Searle to $\eta = \mathrm{CMT}/(l + k)$, where $k$ is the length by which the height, $l$, of the liquid, in the simple theory must be increased, in order that the increase of couple shall correspond to the viscous action in proximity to the end surface and the edge of the rotating cylinder. The results have been plotted in the form of six curves, each for one value of $l$; these are found to possess a hyperbolic appearance. On examining how MT depends upon $l$ when M is kept constant, the function $\mathrm{F\,(MT}, l)_{\mathrm{M-const.}} = 0$, represents, not a single straight line, but a family of approximately straight lines. Experiments carried out at different temperatures show that the curves $\psi(\mathrm{MT, T})_{l-\mathrm{const.}} = 0$ are of the same character as the former curves. The author concludes that the assumption on which the above formula is based, namely, that $\eta$ is independent of the rate of shearing, seems to be unjustifiable for small values of the rate of shearing in the case of the highly viscous liquid employed. H. H. Ho.

**194.** *Anisotropic Fusion. Ideal Lubricants.* **M. Brillouin.** (J. de Physique et le Radium, 1. pp. 33–38, Aug., 1920.)—Treatises on theoretical physics only recognise two states of isotropic matter, the fluid state and that of the more or less viscous elastic solid. These two states differ in their elasticity. Thus for a fluid in equilibrium the thermodynamic potential is a function of the volume and temperature only, while in the solid isotrope the thermodynamic potential depends on the six components of the deformation (dilation and shearing) with their three invariants, or two for small deformations, in addition to the temperature. In isotropic fusion the principal characteristic is not volume change but the transition from solid to liquid state, *i.e.*, the disappearance of all resistance to shearing stresses. The present paper deals with the corresponding properties of anisotropic solids, and first considers relationships at constant temperature for small deformations, which latter are connected to the elastic forces by 21 coefficients of elasticity. The essential characteristic is the disappearance of one only of the dilatations or of one only of the slips or translations in the thermodynamic potential. In non-cubical crystals the coefficients of translation are not all equal, and it may be assumed that temperature acts differentially on each, so that they will vanish separately at different temperatures. In consequence change of sign in some of these coefficients may produce instability of crystalline form and provoke an allotropic change while conserving the solid state in every sense. Under the influence of a very feeble but prolonged tangential force, the crystal may undergo a considerable change in shape (analogous to the translations of mineralogists). This phenomenon the author terms anisotropic fusion, and treats mathematically in the paper. He states that a large number of the liquid crystals of Lehmann fall into one of three categories which are deduced from the theoretical considerations, although their structure may be assumed still more complex since they contain many kinds of atoms. The equations for double fusion are next considered. A body defined by these equations would be the type for a lubricant between two planes, of which one is fixed and the other moves with a finite velocity. The corresponding translations only provoke a viscous resistance, but the transverse ones bring into play an elastic resistance which produces a consequent limitation. In the author's opinion it is this characteristic of unilateral fluidity or at the most bilateral—and not isotropic—which corresponds to the oiliness of lubricants.

*Lubricants.*—Lubricants which hold well under pressure are evidently anisotropic; practical lubricants are probably very concentrated solutions of a crystalline solid in a very small quantity of a very viscous isotropic fluid, *i.e.*, solutions, which, according to the degree of concentration, will be solids, anisotropic fluids, or liquids. Either by heating or by addition of liquid, the limits of these three states may be displaced. It is the intermediate state which lubricates. Finally the author adds that the neighbourhood of solid surfaces may also influence the properties of the lubricant and that in the superficial layer the lubricant is perhaps entirely solid while anisotropically plastic throughout its mass. This problem is reserved, however, for a later paper. H. H. Ho.

**195.** *Elastic Constants of Sylvine.* **K. Försterling.** (Zeits. f. Physik, 2. 2. pp. 172–174, 1920.)—On the assumption of spherically symmetrical central forces between the separate particles, the molecular theories of crystals give certain relations between the elastic constants $c_{hk}$, which are involved in six equations of the form;

$$-X_x = c_{11}x_x + c_{12}y_y + c_{13}z_z + c_{14}y_z + c_{15}z_x + c_{16}x_y$$

connecting the deformations $x_x$, $y_y$ on the one hand, and the elastic tensions $X_x$, $Y_y$, on the other. Through the inverse equations $-x_x = S_{11}X_x + S_{12}Y_y + \ldots$, the elasticity moduli are defined. The existence of these relationships has not in general been established by experiment, and modern theories of crystal structure have usually avoided this difficulty by assuming the crystal to be built up of a series of lattices. In simple cases, such as rock-salt and sylvine, the relation $c_{12} = c_{44}$ is obtained without the introduction of any new hypothesis. While Voigt's data for rock salt gave $c_{12} = 1{\cdot}32 \times 10^8$, and $c_{44} = 1{\cdot}29 \times 10^8$, for sylvine the values are $c_{12} = 0{\cdot}198 \times 10^8$ and $c_{44} = 0{\cdot}655 \times 10^8$ and appear to require an extension of the theory. The author now presents compressibility data for sylvine crystals in order to find which of the values for $c_{hk}$ is invalid. The relationship $c_{12} = c_{44}$ has been very exactly verified; and the simple lattice theory shown to be in accord with Voigt's measurements for sylvine as also for rock salt. .Complications arise, however, in the case of less simple molecules such as fluorspar. H. H. Ho.

**196.** *Bifilar Method of Measuring the Rigidity of Wires.* **G. F. C. Searle.** (Cambridge Phil. Soc., Proc. 20. pp. 61–69, Sept., 1920.)—In this method the couple due to the torsion of two similar wires is balanced against the couple due to the load carried by the wires and arising from bifilar action. Two wires are soldered into torsion heads passing through a firm horizontal support. The lower ends of the wires are secured without initial torsion to a bar so that they are parallel. The bar is provided with a pointer at each end and carries in its centre a load slung by a link which is provided with a knife-edge. The knife-edge rests in a V-groove in a plate which can be adjusted along the bar until the knife-edge is in the position giving equal tensions in the two wires. When this adjustment is effected the wires emit the same note on being plucked. The movement of the bar is best observed optically by means of a plane mirror attached to it and a telescope and scale. If each torsion head be turned from zero through $\phi$ radians in either direction the bar will turn in the same direction until the bifilar and torsional couples are equal. If the bar turns through an angle $\theta$, the whole twist on each wire is $\phi - \theta$. Let the radius and the length of each wire be $r$ cm. and $l$ cm., and the rigidity $n$ dyne cm.$^{-2}$. Since the wires are nearly vertical, the couple, due to torsion, exerted by the pair upon the bar is $\pi n r^4(\phi - \theta)/l$ to a close approximation. The small couple due to the *bending* of the wires assists the bifilar couple; Kohlrausch takes account of this small couple by writing $G = a_1 a_2 \sin\theta \,.\, Mg/l'$, where G is the couple applied to the bifilar suspension, $a_1 a_2$ are half the respective distances apart of the top and bottom ends of the wires, M is the mass in gm. carried by the suspension and $l' = l - r^2\left\{2\pi E/Mg\right\}^{\frac{1}{2}}$, E being Young's modulus. Equating the torsional to the bifilar couple we have $\sin\theta = C(\phi - \theta)$, where $C = \pi n r^4 l'/Mga_1 a_2 l$. Hence $n = ga_1 a_2 l MC/\pi r^4 l'$. Practical details of the method of experiment are fully described and a numerical example is given. A. W.

**197.** *Two-Dimensional Elasticity in Bipolar Coordinates.* **G. B. Jeffery.** (Roy. Soc., Phil. Trans. 221. pp. 265–293, Nov. 8, 1920.)—Gives a treatment of the two-dimensional elastic system by bipolar coordinates, in which the coordinate curves are coaxial circles. This solution can be applied to an infinite plate containing two circular holes, a semi-infinite plate bounded by a straight edge and containing one circular hole, or a circular disc with an eccentric circular hole. One particular result discussed in detail is that of a semi-infinite plate with a straight unstressed boundary and a circular hole under a uniform normal pressure. The solution shows that if the ratio of the radius of the hole to its distance from the edge is suitably adjusted, the point of greatest tension will be on the straight edge, while the point of greatest stress difference is on the circular boundary. It thus suggests a test for the two theories of rupture. The paper is mathematical and cannot be usefully abstracted. J. W. T. W.

**198.** *The Anomaly of the Nickel Steels.* **C. E. Guillaume.** (Phys. Soc., Proc. 32. pp. 374–404, Aug., 1920. Fifth Guthrie Lecture.)—This lecture deals first at some length with the study of the nickel steels, their classification by magnetic properties; their volume changes, both reversible and irreversible; the effect of additions; the elastic properties; progressive and transitory variations, concluding with an outline of the theory. It next describes some of the applications of invar, dealing in particular with the measurement of time and how this has been improved. As a result of the discovery of invar of constant elastic modulus at all ordinary temperatures [Abs. 1118 (1920)], it is probable that the best balance wheel in a watch will soon be equalled by one of a single metal, used in conjunction with a spring of the new alloy. L. H. W.

**199.** *Measurement of High Degrees of Hardness.* **J. Innes.** (Inst. Mech. Eng., J. No. 7. pp. 915–932, Nov., 1920.)—Discusses the definition and measurement of hardness and shows that hardness depends on the elastic properties of a material. Assuming that the elasticity of the indenting tool is equal to or considerably greater than that of the surface to be examined and that the tool is an ideally rigid body, then $H = \frac{\pi^3}{96} \cdot \frac{(3 + 4N)^2(3 + N)}{N^3} \cdot \frac{Q^3}{C^2}$, where N is the ratio of modulus for change of size to modulus for change of shape, C the modulus for change of shape, and Q the limiting shear stress. The conditions represented in this equation appear to be convenient as a definition of hardness, but if the conception of an ideally rigid body be regarded as illegitimate, it is only necessary to suppose the tool and surface made of the same material. The value of the hardness thus defined is four times as great as it would be under the "rigid tool" definition. The three factors required can be determined easily. There are few recorded measurements of Q for brittle materials, and for these solid specimens may give satisfactory results, especially if the measuring arrangements are autographic and the stress is rapidly and steadily increased to the breaking point without jolts and stresses, for example by means of water or shot loading.

C. O. B.

**200.** *Tension Tests of Materials.* **E. G. Coker.** (Engineering, 111. pp. 1–4, Jan. 7, 1920.)—An application of the photo-elastic investigations previously described [see Abs. 182 (1920)] to the case of test-pieces for tensile strength tests of metals. The observations described were made on test-pieces of three shapes, namely: (1) a flat bar four units wide with symmetrically disposed semi-circular notches of unit radius; (2) a flat bar of I-form in which the straight central portion is connected with ends of larger section by arcs of circles of (*a*) very short radius, and (*b*) long radius; (3) the Engineering Standards Association form of test bar.

The distribution of stress between the notches in case (1) was found to be very complex. In case (2) the tensions reached near the angle were high, especially in the case of the sharply curved join. In case (3) the region of complex stress does not penetrate far into the gauge length, but just beyond the junction of the straight portion with the connecting arcs the stress rises to a maximum which is some 20 % above the value of the stress in the gauge length. J. W. T. W.

**201.** *Prism-Hardness ; New Test of Hardness.* **B. P. Haigh.** (Inst. Mech. Eng., J. No. 7. pp. 891–913, Nov., 1920.)—Discusses the definition of the term "hardness" and enumerates the principles relating to a new test of hardness. A new method of testing hardness in materials is described in which a pair of test-pieces of the same material are used and made to indent one another. These test-pieces consist of square

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prisms placed crosswise with their edges in contact and they are pressed together by a measured load. In this test the form of indentation is quite independent of the load, provided that the indentation is not too large in proportion to the dimensions of the test-piece. Consistent hardness values may be deduced by dividing the applied loads by the squares of any characteristic linear dimension of the indentations produced, width or depth, according as one or the other may be preferred. Depths may be measured while the test-pieces are still under load and a series of readings may be taken under successive loads. Widths can be measured with greater accuracy, and the resulting hardness value is practically independent of the angle of the prism within wide limits. In the tests described, the width was measured from corner to corner ($x$) and used as the characteristic linear dimension of the indentation due to the measured load P. Prism hardness is then defined as the quotient $P/x^2$ which may be expressed in units of tons per sq. in. or kg. per mm.$^2$ The apparatus used for the test is described and results obtained experimentally for different metals are given. C. O. B.

**202.** *Rotation of the Non-Spinning Gyrostat; Application to Aeroplane Compasses.* **G. T. Bennett.** (Cambridge Phil. Soc., Proc. 20. pp. 70–73, Sept., 1920.)—If a symmetrical wheel free to rotate about its axle is moved from rest in any position by means of the axle and is finally restored to a position in which the axle again points in the same direction as formerly, it can be shown that the wheel, again at rest, will have rotated through a plane angle equal to the solid angle of the cone described by the varying directions of the axle. This result can be extended to the case in which the initial and final directions of the axis are different, say $a$ and $b$. For the axis may be restored to its original direction $a$ by a subsequent movement in the plane $ba$; and this latter movement, which is a rotation about the normal to $a$ and $b$, leaves unaltered the angle that any diameter of the wheel makes with the plane $ab$. Hence the original movement, shifting the axis of the wheel from $a$ to $b$ by any conical movement, alters the angle between the plane $ba$ and any diameter of the wheel by an angle equal to the solid angle enclosed by the cone formed by the conical surface $ab$ together with the plane $ba$. A geometrical integration of Euler's equation is shown to lead to the same result as given above. The phenomenon has important practical applications, particularly to aeroplane compasses during a banked turn. Some of these applications are briefly discussed. A. W.

**203.** *Effect of Earth's Rotation on Pendulum.* **G. Livione.** (N. Cimento, 20. pp. 19–40, July–Aug., 1920.)—A study of the effect of the earth's rotation on the path of a pendulum bob. It is found that the equation to the path may be expressed in the form $x = a\cos\theta$, $y = \left\{b + b'(1 - \cos\theta)\right\}\sin\theta$. If the approximation be made that $b' = 0$, then the path becomes an ellipse. J. W. T. W.

**204.** *Flight of Projectiles and "Ondes de Choc."* **C. Dévé.** (Comptes Rendus, 171. pp. 665–667, Oct. 11, 1920.)—Describes the conclusions arrived at by the author concerning *ondes de choc*, both primary and secondary. These conclusions are the result of photographic examination of the region surrounding a stationary projectile when in a high-velocity stream of air. The author states that (1) a shock wave is formed at every region of rapid pressure change; (2) at each point in a wave its form depends on the directions and relative speeds of the air-streams at this point; (3) for speeds greater than that of sound, the air ripples over the nose surface, and numerous small waves attach themselves to this surface as if it were corrugated. As a result of (2) it follows that each point of the projectile touched, without deflection, by a wave is a point of the projectile which offers only a very slight resistance to the air. (4) Waves produced by a sharp lowering of pressure are attached, not at the point of pressure-fall, but at the point of impact of the air returning to fill the partial vacuum. (5) If a wave could be instantaneously transmitted from one current of air to another moving at a different speed, the angles of incidence and refraction of the wave would be related by the formula: $1/\sin r - 1/\sin i = V/a$, where V is the relative velocity of the air streams, and $a$ is the velocity of sound.

It follows from conclusion (5) that under certain conditions internal reflection of a wave may take place, but as the transition from one stream velocity to another is always gradual, the effect is similar to the mirage in the case of light. Thus, in the interior of an air stream, a shock wave meeting the mirage surface is reflected at the edge of the stream. When manometer measurements are made for the pressure exerted by an air stream on a projectile, the figure obtained is too low if the nose wave is not properly reflected from the mirage surface, and this effect shows that the projectile dimensions are too great to give reliable results in the current of air used. J. W. T. W.

**205.** *Air Forces on Circular Cylinders.* **H. L. Dryden.** (Bureau of Standards, Bull. 16. pp. 489–519 [Sci. Papers, No. 394], 1920.)—Describes the results of experiments, made in the wind tunnel of the Bureau of Standards, on the air forces on a circular cylinder with its axis normal to the wind. A description of the wind-tunnel is given in the paper, and the results obtained are shown graphically. It is concluded that the wind-tunnel resistance equation $R = \rho AV^2 f(VL/\nu)$ is not satisfied, but that the resistance coefficient R is a function of L, the diam. of the cylinder, as well as of $VL/\nu$, where $\nu =$ viscosity$/\rho$. The velocity fields about cylinders of different diams. at identical values of $VL/\nu$ are not geometrically similar. The departures observed must be due either to correction factors omitted in the above approximate form of the head-resistance equation written above, or to some further property of the air involved. It is suggested that such property may be that involved in the size of the vortices formed behind the cylinders. For, when two circular vortices are close enough together, the separate parts of each vortex will have different velocities, the vortex will, therefore, be distorted, and its effect can no longer be considered as that of a filament Such an assumption would account for the general nature of the observed variations of the resistance coefficient. J. W. T. W.

**206.** *The Formal Basis of the General Theory of Relativity.* **A. Einstein.** (Preuss. Akad. Wiss. Berlin, Ber. 41. pp. 1030–1085, 1914.)—During recent years the author, in partial collaboration with Grossmann, has worked out a generalisation of the theory of relativity. This has involved such a mixture of physical and mathematical demands, that a formal mathematical statement is needed to fill up the various gaps which exist. This the author attempts to do in the present paper, which treats the

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subject under five main sections. Herein the equations of the gravitational field are obtained by a purely covariant theoretical method. Simple derivations, which are in part new work, are given for the fundamental laws of the absolute differential calculus, in order to relieve the student from having to consult purely mathematical treatises. In order to illustrate the mathematical methods, the hydrodynamic equations and the field equations of the electrodynamics of moving bodies have been derived. Newton's gravitational theory is shown to be an approximation of the general theory, and the elementary characteristics of the Newtonian gravitational field (curvature of light rays, displacement of spectral lines, etc.) are derived. Section A deals with the basic ideas of the theory. Section B discusses the theory of covariants. In Section C the equations are derived for the physical processes in a given gravitational field, and include the impulse energy hypothesis for material operations, the equations of motion for continuous mass distribution, and the electromagnetic equations (the Lorentz equations for *vacuo*, equations of moving bodies of unit dielectric constant and unit magnetic permeability, field equations for isotropic, electric, and magnetic polarisable bodies in motion etc.). Section D investigates the differential laws of the gravitational field and includes a proof of the necessity for limiting the choice of coordinates, covariance respecting linear transformations, a suitable system of coordinates, the H- tensor, etc. Section E discusses the physical significance of the general laws developed, and deals in particular with the Newtonian theory. H. H. Ho.

**207.** *Submarine Physics.* **C. V. Drysdale.** (Inst. El. Eng. J. **58.** pp. 572–597, July, 1920. Eleventh Kelvin Lecture. Abstracts in: Electrician, **85.** pp. 391–393, Oct. 1, 1920. El. Rev. **87.** pp. 379–382, Sept. 17; 409–411, Sept. 24, and pp. 442–443, Oct. 1, 1920. Engineering, **110.** pp. 484–486, Oct. 8; 521–523, Oct. 15, and pp. 552–554, Oct. 22, 1920.)—The author deals with questions of general scientific research in the physics of the sea, and practical developments of navigational interest, arising out of investigations carried out at the marine stations established by the Admiralty during the period extending from Nov. 1915 to the middle of 1918. The primary objects were the development of methods of detection and destruction of, and defence against, submarines, and of increasing the safety and regularity of navigation. The physical properties of sea water and also sea conditions do not appear likely to afford much scope for the detection and location of submarines or other solids in the sea by electromagnetic, optical, or thermal methods. Consequently the successful and promising devices are mainly acoustic. Non-directional, uni-directional, and bi-directional hydrophones are described, and their use in determining the direction of a moving submarine from the sound of its engines by means of internal and towed listening devices, amongst the former being those very interesting integrating devices the H tube of H. W. Hilliar and the French naval invention, the "blister" Walser gear. Amongst echo methods for locating stationary submarines, and also rocks, ships, or icebergs, the author considers the Wrightson syren, the Fessenden oscillator, and the Lewis Richardson high-frequency acoustic detector, in which a beam of sound waves is employed of frequency from 5000 to 100,000 per. sec.

In connection with the mine-fields for the destruction or exclusion of submarines, the author gives interesting explosion time-pressure curves for charges of gunpowder and of amatol, respectively, and describes the use of ordnance trial small gauges and piezoelectric pressure gauges employed in obtaining them, together with that of the kathode-ray oscillograph for the recording of rapidly varying pressures. An interesting example of such records shows that the reflection of the pressure wave from the sea bottom produces an impulse comparable with the initial one. The navigational applications include the "leader gear," consisting of a cable carrying an alternating current laid on the sea bottom and marking the centre of the channel forming the entry to a port, together with the observing apparatus by aid of which a ship is enabled to follow the path marked out, enabling ships to find and enter a harbour in a fog; sound ranging and directional radiography; echo detection. The two latter methods are employed for the detection and location of ships and obstacles in darkness and fog. Appendices give the mathematical theory of:—(1) Acoustic transmission; the close analogies of the acoustic and electric equations is pointed out. (2) Three-station sound ranging. (3) Electromagnetic wave propagation in isotropic conducting media with application to sea water. (4) A.C. transmission through large conductors. (5) Current and field distribution in a conducting medium surrounding a live a.c. cable. Apparatus for a rigorous experimental examination of the field surrounding an a.c. cable, with return through the sea, is described, and the investigation is to be carried out at the Shandon station. The mathematics indicate as the principal cause of the apparent anomalies observed in the field, the "skin effect" in the water, causing the return current from the free cable end, through the sea, to crowd in upon and over the cable; as the main secondary cause, refraction of the electromagnetic waves in passing from sea into air. Observations show, further, the existence of electric currents arising from tidal and wave motion in the earth's magnetic field.

G. W. de T.

**208.** *Alternative View of Relativity.* **F. Slate.** (Phil. Mag. 40. pp. 31–49, July, 1920.)—The author continues the argument of a former paper [Abs. 967 (1920)], that restoring, in Newton's methods, the broader connection of force with "Quantity of motion" leads to the view that they are properly equivalent procedures. The narrowing of Newton's methods arose largely from undue stress being laid on certain particulars of rigid dynamics. As an example of the restoration of broader conceptions he instances J. J. Thomson's fruitful expansion of the idea of "effective inertia," and argues that the more thoroughgoing ascription of variable inertia to electrons, as a starting point either for Newtonian dynamics or for relativity, carries with it nothing forced, nor subtle, nor unique into the equations of motion, activity, and work. Our dense ignorance of detail in atomic and electronic systems compels us to leave much undetermined, beyond the proof of inertia through observed energy partitions, and neither Newton nor Einstein escape this; and the fullest employment of their united suggestions must mark the sanest course in adjudicating questions, there or in regard to gravitation. Further detailed comparisons of formulæ supply further links of interrelation between the two methods, and whatever yokes standard dynamics and relativity for joint service based on complete reciprocal consistency—this line of approach seeks. Yet preferential choice may remain open to individual opinion, and may prove to shift with the class of problem under consideration. Some resettlement of rating is scarcely avoidable in that the rigid dynamics of Einstein's theory becomes a convergence point of two more general forms, under approximations through $\dot{m} = 0$ or $c = \infty$ alternatively. For it is not tenable that broader Newtonian dynamics itself reduces directly from relativity by neglecting, in the latter, terms containing powers of $1/c$. We find the same reduction factor in Einstein's "Addition theorem for velocities" as in the Newtonian form. But in the former it expresses the dependence of velocity upon the specifying frames, while in the latter it represents a constant difference of any pair of corresponding values. Since the characteristic factor of the theorem appears spontaneously in a dynamic relation of the two frames, the intrinsic meaning of the theorem must go deeper, and the author concludes that this deeper meaning is to be found in the existence of a self-suggested frame, which is basic for physical phenomena in the sense that departures from it, either by rotation or translation, impress distortions of common type upon physical magnitudes. The author claims that the cumulative effect of his arguments tends to substantiate Lorentz's claim for the existence of "true time" and of frames at rest in the ether. G. W. DE T.

**209.** *Atomic Structure.* **N. R. Campbell.** (Nature, 106. pp. 408–409, Nov. 25, 1920.)—The arrangement of the non-nuclear electrons in the atom is being determined by work along two lines: first, from the Bohr-Sommerfeld theory of characteristic frequencies, and, secondly, from the Lewis-Langmuir or Born-Landé theory of the structure of molecules, supported by Bragg's work on atomic radii in crystals. It has been stated several times recently, that the conclusions drawn from the two sources are mutually inconsistent, in that the first indicates that the electrons are revolving in planetary orbits, and the second that they are fixed in constant positions. The essential truth of the first theory is now beyond doubt, and the present writer's object is to insist that the theories are not really inconsistent. The Bohr-Sommerfeld theory does not make explicit use of the assumption that the electrons in their stable states are moving; it assumes only that in those states they have the energy, calculated by Hamiltonian (relativity) dynamics, which they would have if they were moving in certain orbits. It is not logically impossible to maintain that they have that energy and are yet at rest. Nor is it physically impossible if Bohr's principle of correspondence be accepted, which latter has been so successful in explaining the Stark-effect and in predicting the number of components in lines of the hydrogen and helium spectra. According to that principle, the intensity and polarisation of components can be predicted by the application of classical dynamics to certain assumed orbits, although it must be assumed at the same time that the electrons are not moving in those orbits. If intensity and polarisation can be predicted from orbits that are wholly fictitious, why not energy? The adoption of Bohr's principle in this extreme form would sever the last connection between classical dynamics and the real structure of the atom. The writer, however, opines that all are convinced that part of that connection must be abandoned, and he asks if there is any reason but mere conservation which causes hesitation in abandoning the whole of it and admitting that even in respect of energy, a fixed electron can have the properties which classical dynamics attributes to a moving electron. Classical dynamics, it is clear, is only statistical;

what are the principles of the elements of the statistical group is the main problem of the physics of the future. H. H. Ho.

**210.** *Velocity of the Positional Change of Ions in Crystals.* **G. v. Hevesy.** (Zeits. f. Physik, 2. 2. pp. 148–149, 1920.)—When the Einstein relation between diffusion and mobility is applied to the case of salt crystals, and from the conductivity of the crystal the velocity with which the ions in a single crystal change their positions is calculated, infinitesimal values are obtained at ordinary temperatures; *e.g.*, for the case of rock salt the value at 20° is scarcely $3 \times 10^{-18}$ cm.$^2$ per day, *i.e.*, $10^{18}$ times smaller than in the sodium chloride melt. On heating, the value is rapidly accelerated; *e.g.*, at 150° it is already 200 times quicker than at ordinary temperatures. At the fusion point an abrupt change in the conductivity occurs, although the fusion process itself begins somewhat previous to this, and with alkali nitrates later than with chlorides; the reverse being the case with the halides of the heavy metals. Although no means are at present to hand for following the positional change of the ions in common salt, yet for solid lead chloride the aid of radio-active indicators is available, and the diffusion velocity of the chloride of an active lead isotope in inactive lead chloride may be studied. Brief experimental details are given for the latter determination. In mixed crystals the change is as a rule more pronounced than in crystals of single components, but is also infinitesimal in the cold. Tammann's work is briefly mentioned, including his conclusion that an appreciable positional change occurs between the atoms of mixed crystals at high temperatures which are still, however, below the melting-point. H. H. Ho.

**211.** *Stability of Atoms. The Hydrogen, Helium, $H_3$, $H_2$ Theory of Atomic Structure.* **W. D. Harkins.** (Am. Chem. Soc., J. 42. pp. 1956–1997, Oct., 1920.)—The present paper is an extension of earlier papers on the same subject [see Phys. Rev. 1915, 1916, 1917, and 1919, also Abs. 1123 (1919)]. Using as a basis the evidence obtained from the electrolysis of solutions, from the positive-ray work of Thomson, and from the atomic weights of the elements and of the separate atomic species, insofar as the latter were then known, the author presented the theory that the nuclei of all atoms are made up of positive and negative electrons, and evidence was given which indicated that the nuclei of hydrogen atoms are positive electrons. In the present paper it is shown that in the nuclei of the lighter elements there are in general about half as many negative as positive electrons, and that in no known complex nucleus is the ratio of negative to positive ions less than one to two.

The theory indicated that the deviation of the atomic weight of helium (3·969 when hydrogen = 1) from a whole number is due to a "packing effect" which amounts to a decrease of mass of 0·77 %. This theory was based on the idea of Rutherford that the nucleus of the atom is very minute. A. B. W.

**212.** *Size of the Kations of Alkali Metals.* **R. Lorenz.** (Zeits. f. Physik, 2. 2. pp. 175–180, 1920.)—The paper is an addition to the tables of Born and of Heydweiller on the radii of alkali kations, and is based upon the author's views as to the relation between space-filling and ionic mobility. He tabulates for Li, Na, K, Rb, Cs, the atomic volume A; the radius $R_A$ calculated from A; the $R_W$ radius from Born's heat

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of hydration W; the $R_B$ from the new ionic mobilities calculated after Stokes-Born; the $R_G$ from Landé's lattice constant G; the $R_R$ from Heydweiller's ionic refraction R, the $R_R$ and $R_G$ values being in good accord; the $R_D$ from the diffusion D of the alkali metals (not ions) in mercury after Meyer and Wogau and Stokes-Einstein; the $R_\psi$ radius corresponding to the smallest space-filling $\psi = 0 \cdot 25$; finally the $R'_W$, obtained by diminishing $R_W$ by the radius of a water molecule (as suggested by Born). The last two columns are in striking agreement. H. B.

**213.** *Lewis and Langmuir Atomic Models.* **O. R. Foster.** (Chem. and Met. Eng. 23. pp. 690–692, Oct. 6, 1920.)—The paper contains photographs of atomic models constructed by L. Lefferts, in accordance with the Lewis-Langmuir theory, of various elements and compounds, together with a detailed description of the method of construction from simple and inexpensive material. G. W. DE T.

**214.** *Composition, Ionisation, and Viscosity of the Atmosphere at Great Heights.* **S. Chapman** and **E. A. Milne.** (Roy. Meteorolog. Soc., J. 46. pp. 357–396; Disc., 396–398, Oct., 1920.)—*Composition.*—Evidence of the presence of hydrogen in the stratosphere is not conclusive, and the composition, pressure, and density of the atmosphere at great heights have accordingly been recalculated both on the assumption that hydrogen is present and that it is not. If it is absent, then above 150 km. the atmosphere is almost entirely helium. It is shown that the hypothetical geo-coronium, suggested by Wegener, could not be retained by the earth on account of the low molecular weight, 0·4, so this gas is not considered as being present. The effect of mixing in the troposphere is to render the composition of the atmosphere practically the same throughout this region. There is, however, no reason to suppose that mixing ceases suddenly at the top of the troposphere, for although it would tend to destroy the nearly isothermal condition of the stratosphere, yet the effect of a limited amount would be counteracted by radiation. A theoretical examination is accordingly made, of the effect on the composition, etc., at great heights, of varying the level at which diffusive separation of the gases commences and the calculations are performed, taking this height successively as 12 km., 20 km., 30 km., and 50 km. The general result is that up to about 100 km. there is little effect on the pressure and density, but above 150 km. these are very sensitive to variation in the assumed height at which mixing ceases.

*Ionisation.*—Using the results of these calculations, the distance to which α-particles could penetrate the atmosphere from outside is investigated. Assuming the particles to possess, at the outer fringes of the atmosphere, velocities such as are observed with α-particles emanating from radio-active substances, it is found that, if incident directly, the fastest could penetrate to a height of 80 km. and the slowest 85 km., and this is independent of the level at which diffusive separation is supposed to commence and of the presence or absence of hydrogen. This result is to be contrasted with that of Vegard who, using Wegener's pressures (geo-coronium present) finds, for example, that the height reached would be 200 km. for α-particles with the initial velocity of those from RaC. The importance of these results is in their bearing on the theory of auroræ (which are confined to the layer 100 km. to 130 km.), that they are the manifestation of the absorption by the atmosphere of α-particles emitted by the sun. The penetration of the atmosphere by β-rays and γ-rays is also considered. They would give rise to two well-marked layers of max. ionisation at about 54 km. and 26 km. respectively.

*Viscosity.*—As regards viscosity, there is a rapid increase in the effective kinematical viscosity at great heights owing to the decrease of density. M. A. G.

**215.** *Distribution of Precipitation in North Germany.* **G. Hellmann.** (Preuss. Akad. Wiss. Berlin, Ber. 38. pp. 980–990, 1919.)—The region considered is, roughly, that part of Germany lying north of lat. 50° N. Charts and data, showing monthly and yearly averages based on twenty years' observations are published elsewhere, and the general results are discussed in this paper. Two tables are at present devoted to yearly averages, the one giving this information for individual provinces and the other showing the percentage area of each province which receives an annual rainfall between given limits. Posen is the driest (509 mm.), 42·4 % of the area receiving less than 500 mm., 57·1 % between 500 mm. and 600 mm., and 0·5 % between 600 mm. and 700 mm. The wettest is Westphalia (807 mm.), 50·4 % receiving between 700 mm. and 800 mm., while, quoting extremes, 1·1 % receives between 500 mm. and 600 mm., and 1·1 % between 1200 mm. and 1400 mm.

Monthly averages are expressed as percentages of the yearly sum, and three types of yearly distribution are recognised, according to the position of the maxima; (1) a single maximum in a particular month, (2) one or more secondary maxima, (3) a transition type in which a month adjacent to a maximum is almost as high itself. A map shows the distribution of these types, the salient features being that type (1) with a July maximum is by far the most extensive and that there is a general transition from a June maximum in the south to an October maximum in the north, Sept. being passed over without showing as a maximum in any district. The driest month is March in E. Prussia, Feb. in the central regions, and April in the west. The distribution of the amplitude, expressed as a percentage of the yearly sum, is illustrated by a map which shows a decrease from 12·5 % in the east to 3·5 % in the west, with a tendency for areas of maximum on the lee side of mountains. There is a rapid decrease with altitude in mountain districts.

M. A. G.

**216.** *Ether Differential Radiometer.* **W. H. Dines.** (Roy. Meteorolog. Soc., J. 46. pp. 399–405; Disc., 405–406, Oct., 1920.)—*Apparatus.*—The instrument consists essentially of a sensitive differential thermometer formed by two test tubes, each containing a few drops of ether, mounted with their axes in a horizontal line and communicating with each other by a U-tube containing ether to form a pressure gauge. A metal shield is placed round each tube, with a horizontal slit to admit radiation. The direction from which radiation is admitted to either tube can be controlled by rotating the appropriate shield about the common axis. *Method of Use.*—There are two ways of using the instrument. In the direct method radiation from a portion of the sky is allowed to fall on one tube while the other is exposed to a full radiator, a vessel containing water, the temperature of which is altered until a balance is obtained. The equivalent radiative temperature of the sky (*i.e.*, the downward radiation from the

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atmosphere) is then equal to the temperature of the full radiator. In the indirect method, instead of altering the temperature of the full radiator, the tube exposed to the sky is allowed to receive radiation from a second full radiator, of constant temperature, so placed as to effect a balance. A simple calculation then gives the equivalent radiative temperature of the sky.

*Equivalent Radiative Temperature of the Night Sky.*—Observations taken intermittently from Sept. 1919 to Feb. 1920 have given equivalent radiative temperatures of the zenith sky ranging from 180° to 280° abs., the lower values being confined to winter. Some later observations in June gave values about 264° abs. on clear nights. The seasonal range is certainly much greater than that of the actual air temperature, which is about 10 deg. C. On heavily clouded nights the sky temperature differs little from the surface air temperature. Wind appears to make no difference to the radiation. It is estimated that on clear nights the average rate of net radiation from the earth (for the whole hemisphere) is about 150 gm. cals. per day, though the rate may reach 250 gm. cals. per day.

As regards radiation at various zenith distances, the approximate relative values of the net radiation, 100 denoting the net radiation to the zenith, found for clear nights in the last fortnight of May, were :—

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Altitude ............ | 90° | 75° | 60° | 45° | 30° | 15° | 0° |
| Radiation.......... | 100 | 99 | 96 | 89 | 73 | 43 | 0. |

M. A. G.

**217.** *Variations in the Density of Air.* **A. Jaquerod and C. Borel.** (Arch. des Sciences, 2. pp. 411–413, Sept.-Oct., 1920. Paper read before the Soc. Suisse de Physique.)—The authors describe briefly some refined determinations of the density of air, made by them at Neuchâtel, with the object of investigating the unexplained variations in the density pointed out by Morley as long ago as 1875. The law of Loomis–Morley is confirmed, namely, that the max. density is found with samples of air taken when the atmospheric pressure is a minimum, and *vice versa*. Differences of composition do not seem sufficient to explain these variations, and Guye has suggested that the cause is to be found in the presence of ultra-microscopic dust. To test this the authors propose to experiment with air from which dust has been removed electrically. Samples of air obtained by aeroplane from altitudes between 2 km. and 3 km. have been tested and appear to be subject to the same variations of density as the surface air. M. A. G.

**218.** *Ionisation in the Solar Chromosphere.* **M. N. Saha.** (Phil. Mag. 40. pp. 472–488, Oct., 1920.)—Enhanced lines are a characteristic of the chromosphere, but Lockyer's suggestion that the enhancement is due to higher temperature is untenable, as otherwise the temperature of the solar envelope would be increasing outwards, which is physically impossible. The author's alternative suggestion is that the substances in the higher levels are more intensely ionised, *i.e.*, atoms deprived of one electron. He considers that the high-level chromosphere is chiefly composed of ionised atoms of Ca, Ba, Sr, Sc, Ti, and Fe, while in the lower layers such atoms are mixed with neutral ones. An explanation is sought, consistent with Nernst's theorem of the "Reaction-isobar," assuming the ionisation to be a sort of reversible chemical process. The electron is assumed to be a monatomic gas with atomic weight 1/1836. The equation found shows the great influence of pressure on the degree of ionisation. Ca, Ba, and Sr are almost completely ionised in the low-pressure high-level chromosphere. H is completely dissociated everywhere in the solar atmosphere, for otherwise the presence of any molecular H would be shown by the appearance of at least some of the lines of the secondary spectrum. If any of these H-atoms should be ionised there would be nothing left to radiate, so nothing would be visible. Thus practically H is not ionised. Helium is a difficulty, as it appears possibly more ionised in the lower levels, but the author considers that He cannot be appreciably ionised except in the very hottest stars, where alone the characteristic Rydberg line 4686 can be shown. W. W. B.

**219.** *Diffusion and Absorption in the Solar Atmosphere.* **K. Schwarzschild.** (Preuss. Akad. Wiss. Berlin, Ber. 47. pp. 1183–1200, 1914.)—This paper gives a mathematical treatment of the effect of the sun's atmosphere (considered as lying outside the photosphere) on the intensity of the spectrum, and within the Fraunhofer lines, when using light (1) from the centre of the sun, and (2) from the outer edge. [See Abs 1347 (1905).] A. W.

**220.** *Displacement of the Band λ3883 in the Solar Spectrum.* **K. Schwarzschild.** (Preuss. Akad. Wiss. Berlin, Ber. 47. pp. 1201–1213, 1914.)—Extremely careful measurements were made of the nitrogen band lines beginning at λ3883 Å. in the solar spectrum. Comparison with the corresponding lines obtained from a terrestrial light-source showed a displacement of about 0·003 Å. towards the red, corresponding to a velocity of 0·2 km. per sec. The stronger lines gave in general a greater displacement than the weak ones. The same effect has been observed by Evershed and Royds for iron lines in the solar spectrum and from a terrestrial source, the observed displacement towards the red being greater for the stronger lines. The results obtained up to the present do not confirm Einstein's theory, which requires a displacement corresponding to 0·63 km. per sec. More results are required before an accurate discussion of the subject can be attempted. [See Abs. 1468 (1911).]
A. W.

**221.** *Surface Brightness of the Galactic System as seen from a Distant External Point and a Comparison with Spiral Nebulæ.* **F. H. Seares.** (Mt. Wilson Observat., Contrib. No. 191. Astrophys. J. 52. pp. 162–182, Oct., 1920.)—The results recently obtained by Kapteyn and van Rhijn for the distribution of stars of various magnitudes in our galaxy [Abs. 1392 (1920)] have enabled the author to determine the surface-brightness of the galactic system, as viewed from a distant point in the direction of the galactic pole, for various distances from the centre. The brightness of the central part is found to correspond to visual magnitude 23 per square second of arc, whereas probably all known spiral nebulæ are brighter than this; in fact, many nebulæ, including such well-known ones as that in Andromeda, are more than one hundred times as bright. This result indicates that spirals differ from the galactic system by being nebulous, or that they must be much larger or composed of more stars or of brighter stars. Our galaxy is therefore far from being a typical spiral.

Viewed edge on, the brightness of the galaxy would be magnitude 21·2 per square second. These results are checked by comparison with the total amount of starlight in the direction of the pole and the galaxy as computed from star counts.

*Brightness of nebulous areas* may be *determined photographically* by comparing the times of exposure necessary for barely perceptible images, with the exposure necessary to secure a trace of a large extra-focal image of a star of known magnitude. The constants for use with the 60-in. were determined in this way. Since in the case of extended nebulæ, atmospheric disturbances and intermittency losses do not interfere with the continuity of exposure, images were obtained for a given magnitude per square second in the time required for images of stars about three magnitudes brighter. AUTHOR.

**222.** *Spectra of Nova Aquilæ III.* **F. J. M. Stratton.** (Engineering, 110. p. 353, Sept. 10, 1920. Paper read before the British Assoc., Cardiff, Aug., 1920.)—Peculiar changes have been taking place in the distribution of the radiation from the originally greenish disc which was apparently growing in diameter. The growth deduced from H was at only half the rate of that deduced from the two chief Nb lines. Moreover the maxima in the bands from the upper part of the disc did not agree in position or inclination with those from the lower part, suggesting origins in different portions of a system undergoing a very complex combination of expansion and rotation or vortex motion. Assuming that this is a Doppler-effect, the H and Nb must be flowing out at different rates. The maxima remained fixed in position, but the most displaced lines were growing brighter in comparison with the centre, and the nebula seemed to have become spiral in less than two years. W. W. B.

**223.** *Photometric Study of U Cephei.* **R. S. Dugan.** (Astrophys. J. 52. pp. 154–161, Oct., 1920.)—*Eclipsing Variable U Cephei.*—The results of a *photometric study* extending from April 1914 to April 1917, during which 14,112 measurements were made, are collected. The range of variation is 2·28 mag. in primary minimum and 0·09 mag. in secondary minimum and the probable error of each normal about 0·018 mag. With the exception of variation due to eclipse, the *light-curve* is well represented by the equation: $L = 0{\cdot}958 + 0{\cdot}008 \sin\theta - 0{\cdot}021 \cos\theta + 0{\cdot}029 (\sin 2\theta - 42{\cdot}6^\circ)$. The terms after the first are interpreted to indicate: (1) the greater brightness of the advancing side of the bright star; (2) the reflection effect on the darker star; and (3) a tidal lag, at least in the case of the bright star, of about 24°. This last conclusion, combined with the fact discovered by the author that according to the available evidence the period is nine seconds longer than it was sixty years ago, suggests a *tidal evolution* of great interest. The observations also indicate that the star discs are *two or three times as bright at the centre as at the limb.* The *elements of the orbits and other data* are collected at the end of the paper.

B.D. + 81·27° *and* 81·30° were found to be *variables.* AUTHOR.

**224.** *Intensity Distribution in Continuous Spectrum and Intensity of H-lines in γ Cassiopeiæ.* **H. H. Plaskett.** (Roy. Astron. Soc., M.N. 80. pp. 771–782, Oct., 1920.)—The author adapts the method devised by Merton and Nicholson for determining spectral intensities to stellar spectra, and in this paper deals only with the H lines in

$\gamma$ Cassiopeiæ. He gives the essential features of the method and experimental details found necessary in his adaptation. For the resulting intensity curve, corrected for atmospheric transmission, the author finds an accuracy of at least 95 %. The max. intensity is found at $0{\cdot}43\,\mu$. He deduces a temperature of 6800° abs., but finds that one of 10,600° abs. is requisite to ionise enough He-atoms to produce the line $\lambda$4686. He has not yet sufficient evidence to explain the anomaly, but suggests that either the maximum is not at $0{\cdot}43\,\mu$, as it depends upon two measures at the limit of accuracy, or that the true maximum is observed by scattering in the star's atmosphere, or else that the photosphere does not radiate as a black body as it has been assumed to do in obtaining the result.

*Intensity Decrement in the Balmer Series.*—This the author finds to be of the same order in the star as is shown by hydrogen and neon in the laboratory. There is evidence of variation in the intensity of emission lines in $\gamma$ Cassiopeiæ. The contour of the $H_\beta$ line is parabolic and not a straight line. Hence it corresponds to an ordinary discharge, not highly condensed. Yet in the spectrum of the star are many lines such as $\lambda$4686, which do require highly condensed discharges to produce them. The author suggests that the H emission lines are produced at higher levels under different conditions. W. W. B.

**225.** *Comparisons of Photographic Stellar Parallaxes.* **A. S. Flint.** (Astron. J. 33. pp. 95–99, Nov. 16, 1920.)—This paper was laid aside in Feb. 1918, in the hope of including additional parallaxes, which have not been obtained however. It includes results communicated in MS. from the Sproul, Leander McCormick and Dearborn Observatories at the end of 1916, as well as four published series from Yerkes, and one each from Greenwich and Mt. Wilson. The total number of results considered is 325, and these have been treated in three ways. (1) A series of differences between the results for the components of successive pairs of stars whose members are close together, especially in R.A. (2) A series of group means of all chosen photographic parallax results at hand, taken by themselves and adjusted for a difference of parallax with respect to proper motion and spectrum; these to be compared between themselves and also with similar results obtained by other methods and corresponding to the photographic results as near as may be, in distribution, especially in R.A. or time of year. (3) A series of differences on individual stars between the mean of the photographic results and the mean of those from all the selected authorities, including the photographic authorities themselves, which occur on the same individual stars.

The general conclusion, after comparison with three independent sets of parallaxes, is that there is something systematic in the differences between the photographic determinations and those of the older methods, and also possibly a residual depending on the R.A., that is to say on the distribution of the stars in space. W. W. B.

**226.** *Observations of SS Aurigæ and Faint Comparison Stars.* **H. L. Alden** and **S. A. Mitchell.** (Astron. J. 33. pp. 87–91, Oct. 30, 1920.)—This star is of the same type as SS Cygni and U Geminorum, with minimum brightness fainter than 15th magnitude, with frequently a rapid rise to maximum brighter than 11th magnitude. An account

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is given of the precautions observed in determining the magnitudes of the faint comparison stars, one of which appears to be definitely variable. The observations were made chiefly by Mitchell, but four others took part; the period covered by the observations being from 1916 Dec. 17 to 1920 May 3. They were made with the 26-in. telescope of the McCormick Observatory. W. W. B.

**227.** *On the Orbit of a Planet.* **A. Anderson.** (Phil. Mag., 40. pp. 499–501, Oct., 1920.)—This is a short mathematical paper in which the author finds that the ordinary equations for the path of a particle in a central gravitational field result in an equation for gravitation potentials, which do not satisfy Einstein's contracted-tensor equations. He therefore sets out to find some assumption that will produce gravitation potentials which will satisfy these equations, referring specifically to the case of the advance of Mercury's perihelion. He claims that his suggested method is the same as the application of Hamilton's principle, with a simple substitution for the sum of the kinetic energy and the force function. W. W. B.

**228.** *Motion of Magellanic Clouds.* **E. Hertzsprung.** (Roy. Astron. Soc., M.N. 80. pp. 782–784, Oct., 1920.)—R. E. Wilson [see Abs. 1570 1920)] discussed the radial velocity of 17 nebulæ in the greater Magellanic cloud. He found a mean value of 276 km./sec. with marked differences depending on position, the radial velocity being more positive with greater S. Polar distance. To account for this he suggested rotation. The present paper argues alternatively that no such rotation is necessary to explain the figures. The author finds that the simple assumption that all parts of the cloud are moving parallel with the same velocity in space fits the figures quite satisfactorily with a reasonably small mean error. He also maintains that the lesser Magellanic cloud shares the same motion, which is consistent with the radial velocity of the only nebula in it whose motion has been determined. He expects for the two clouds annual proper motions of 0″·0118 in direction 348° and 0·″0127 in direction 55° respectively, so that they will be approaching each other. W. W. B.

**229.** *Spectra of Class N Stars.* **C. D. Shane.** (Lick Observat., Bull. 10 [Circ. No. 329], pp. 79–92, 1920.)—*Nature of Class N Spectrum.*—Two of the brightest N stars in the Northern Hemisphere, 152 Schjellerup and 19 Piscium, have been studied with high dispersion. C, H, Fe, Ti, Va, Cr, Na, Mn, Ca, Sc, and Y have been identified, and probably La, Ba, Cd, and Zr are also present. The low-temperature lines are prominent, supporting the hypothesis that these red stars are the coolest class and possibly are nearest to extinction. Some similarities are found with class M stars and sun-spots. The bright lines are probably due to gaseous emission, but none of them except H lines has been identified. The absorption bands include five C groups of the Swan spectrum, the first showing three narrow bands, while the other four are prominent. The CN group λ4216 is less prominent than in the R class, but that beginning at λ4606 is stronger in the N stars. The inferences drawn as to physical constitution are that the reversing layer is heavy and cool, that above it are the substances producing bright lines, while an outer atmosphere, partly of carbon vapour, surrounds the whole. This outer atmosphere may condense to form occulting clouds which absorb the rays of shorter wave-length and account for the ruddy colour. An increase of this absorption would tend to extinguish the red rays also, and render the star invisible.

*Variation in Class N Spectra.*—Stars having a fairly wide range of brightness may be expected to have a variable spectrum. Several stars whose magnitude varies from 6 or 7 to about 10 have been selected, and of these three, U Cygni, RS Cygni, and R Leporis, have been principally studied. The bright H-lines are absent or very faint except within one or two magnitudes of maximum. The D lines of Na are broad at minimum and narrower at maximum. The C absorption also decreases at maximum. The stars appear redder towards minimum, some unknown lines appear to vary, notably one at λ5845. These variations are distinctly similar to those previously found in stars of class Md, and Merrill's "veil" theory [see Abs. 832 (1920)] is almost equally applicable to the N stars, though it does not account for the behaviour of the D lines.

W. W. B.

# LIGHT.

**230.** *Interferometer for Testing Optical Systems.* (Engineering, 110. pp. 857–859, Dec. 31, 1920.)—Describes the Hilger interferometer used for correcting the curvatures of optical surfaces, and shows photographs demonstrating the method of use, and results obtained with the instrument. The paper concludes with a short mention of the production of mirror surfaces by kathodic sputtering in the case of silver, gold, platinum, and palladium. J. W. T. W.

**231.** *The Absorption of Heat in Glass; Variation with Temperature.* **A. Q. Tool** and **C. G. Eichlin.** (Optical Soc. of America, J. 4. pp. 340–363, Sept., 1920.)—Experimental results are given which show that glass on being heated exhibits within a definite and narrow temperature range a marked increase in its heat absorption, which in many ways corresponds to the cooling effect occurring on a change of state. From a discussion of the possible causes of this effect, it would seem that it may be caused by one or more types of molecular aggregates, which may have a crystalline structure. It is also shown that chilling or annealing glass produces the effect that should be expected, if the absorption of heat on heating and its evolution on cooling are due to the formation and dissolution of some crystalline structure or other molecular aggregate.

*Structural Inhomogeneity due to Certain Methods of Cooling.*—The possibility that certain methods of cooling or treatment may cause structural inhomogeneity in glass through the non-uniform formation of these aggregates is also discussed, and attention has been called to the importance of this possibility in the annealing and other special heat treatments of glass. This would mean that annealing is not alone a question of the removing of stresses, but also of producing homogeneity. AUTHORS.

**232.** *Relative Spectral Transmission of the Atmosphere and an Apparatus for Measurement of Same.* **E. Karrer** and **E. P. T. Tyndall.** (Bureau of Standards, Bull. 16. pp. 377–408 [Sci. Papers, No. 389], 1920.)—*Apparatus.*—The bulk of the paper is devoted to a careful description of the development of an apparatus for measuring the transmission of the atmosphere for light of different wave-lengths, of the methods of eliminating errors, of corrections to be applied, and of tests for the reliability of the results. Briefly, the method is to employ a modified Brace spectrophotometer near which is a source of light, a beam from which is reflected back to the spectra-photometer from a mirror distant 600 m. The intensity of the reflected beam is compared wave-length by wave-length with a beam direct from the source.

*Results.*—The results given in the paper deal with the relative and not the absolute spectral transmission. The transmission at 540 $\mu\mu$ is taken as standard, and observations are referred to three sets of meteorological conditions: (1) overcast and with high humidity, (2) rainy, (3) clear, cold, and low humidity. Throughout every series of observations embracing a range of wave-lengths frequent observations were made at 540 $\mu\mu$, and observed fluctuations in the transmission at this wave-length enabled corrections to be made for variations in the atmospheric conditions during the time occupied by the series of observations. It is found that under conditions (1) the relative transmission increases uniformly from about 70 % at 420 $\mu\mu$ to 100 % at 540 $\mu\mu$. Beyond 540 $\mu\mu$ there is a further slight rise, then a slight fall to a minimum between 590 $\mu\mu$ and 640 $\mu\mu$, followed by a maximum of 110 % to 120 % at about 660 $\mu\mu$. From 660 $\mu\mu$ to 690 $\mu\mu$ there is in this and in the other two cases a decrease, due, it is thought, to absorption by oxygen. In case (2) the effect of rain is to alter that part of the curve representing (1) between 540 $\mu\mu$ and 660 $\mu\mu$, increasing the relative transmission and showing but a single maximum at about 640 $\mu\mu$. In case (3) the transmission increases up to 520 $\mu\mu$, remains uniform from 520 $\mu\mu$ to 660 $\mu\mu$, and then decreases again.

While rain was falling the transmission at 540 $\mu\mu$ was found to decrease as time advanced, an effect thought to be due to the accumulation of fine water-drops in the atmosphere during the rain. Data obtained in this way are likely to be important in many practical problems, including head-lamps for automobiles and locomotives, aerial photography, light-house lamps, and especially the best colour for a searchlight beam.

M. A. G.

**233.** *Reflection of Monel Metal, Stellite, and Zinc.* **W. W. Coblentz.** (Bureau of Standards, Bull. 16. pp. 249–252 [Sci. Papers, No. 379], 1920.)—Gives data on the reflecting power of monel metal, stellite, and zinc, in the visible spectrum and to 4 $\mu$ in the infra-red. In the infra-red the reflectivity of monel metal is practically the same as that of nickel; it varies from 57 % at 0·45 $\mu$ to 91 % at 4 $\mu$. The values found for stellite confirm those previously obtained [see Abs. 343 (1920)]. Zinc shows a deep depression in the reflectivity curve at about 1 $\mu$, followed by an unusually high reflectivity beyond 2 $\mu$. At 4 $\mu$ the reflecting power is 96 %.

J. W. T. W.

**234.** *Diffraction by Small Particles.* **M. v. Laue.** (Preuss. Akad. Wiss. Berlin, Ber. 47. pp. 1144–1163, 1914.)—The commonly accepted view that if a number of similar particles be distributed evenly over a plane, the form of the diffraction pattern does not depend on the distribution of the particles, is shown by the author to result from a fallacy in reasoning from the probability theory. He shows that in reality it is not possible to find the light-intensity at any point without knowing the position of every particle. It follows that there will be radial lines in the diffraction pattern, and this is demonstrated in the paper by means of a photograph of the pattern produced by lycopodium powder scattered over a glass plate.

J. W. T. W.

**235.** *Experiments with a Plane Diffraction Grating in Parallel and Non-parallel Light.* **G. F. C. Searle.** (Cambridge Phil. Soc., Proc. 20. pp. 88–108, Sept., 1920.)—(1) *Parallel Light.*—When a plane grating is employed in accurate measurements of wave-length, the rulings are set perpendicular to the direction of the incident beam of parallel light. When these two directions are not at right angles the diffracted beam is no longer parallel to a plane containing the directions of (*a*) the incident beam and (*b*) a line intersecting the rulings at right angles.

The formulæ applicable to this general case are obtained in sections 4, 5, 6, and 7. Sections 8 and 9 describe an experiment by which the formulæ may be tested for the restricted case in which the directions (*a*) and (*b*) are at right angles.

(2) *Non-parallel Light.*—In the case of non-parallel light the diffraction not merely changes the direction of the axial ray of the beam, but also, in general, introduces astigmatism into, or changes the astigmatism of the beam. The exception is when the incident and diffracted rays are perpendicular to the rulings and the deviation is a minimum. The diffracted rays will, in general, pass through two focal lines when the aperture is small. If the aperture is increased, aberration will appear and all the rays will not pass accurately through the two lines. Aberration can be minimised by keeping the aperture small, but astigmatic effects are inseparable from the diffraction in the general case. The formulæ for the general case are easily obtained, but are complicated. Hence only that case is considered in which the axial ray of the incident beam is perpendicular to the rulings. Formulæ for this case are obtained in Sections 2 and 3. Section 4 gives the simplified formulæ when the incident wave-front is cylindrical, and Sections 5 to 9 deal with an experimental verification of the formulæ derived. A. W.

**236.** *Theory of Powell's Bands and the Group-Velocity in Dispersive Media.* **N. K. Sethi.** (Phys. Rev. 16. pp. 519–525, Dec., 1920.)—*Powell's Bands : Observations with Liquid Mixtures of Variable Refractive Index.*—A description is given of the changes in the position, width, and degree of visibility of the bands seen in the spectrum when a flat-sided cell containing liquid of which the refractive index is gradually varied is placed behind the prism on the table of a spectroscope, a transparent plate of glass being immersed in the cell so as to cover half the aperture. The liquid chosen for the experiment was a mixture of $CS_2$ and benzene, of which the proportions could be altered in any desired manner. Special attention is paid to the *condition of visibility.* Mascart's and Schuster's statements on this point in their treatises are criticised, and it is shown that the side of the cell on which the plate should be immersed is determined not by the relation between the refractive indices of the liquid and the plate, but by the group-velocities in the two media. Owing to the highly dispersive nature of the liquid employed in the experiments, the position of the plate has on this account to be changed from one side to the other at a stage at which the refractive index of the liquid is still lower than that of the plate for the whole of the visible spectrum.

*Powell's Bands : Relation to Laminar Diffraction.*—Spectroscopic analysis of the laminar diffraction either of the Fraunhofer or the Fresnel type formed by the plate immersed in the liquid gives oblique interference lines, photographs of which are given. Their number and the positions at which they cross the spectrum are identical with those of Powell's bands, and their inclination to the direction of the spectrum indicates at once the side on which the plate should be immersed for observation of Powell's bands and the degree of visibility of these bands. The visibility is maximum when the interference lines are inclined at 45° to the length of the spectrum.

*Group-velocity of Light : Direct Determination of the Position of its Identity in Two Media.*—This is rendered possible by the fact that the oblique interference lines mentioned above curve round and become inclined in the opposite direction at this position as shown in the photographs given.

*Determination of Refractive Indices and Dispersive Powers.*—As the oblique interference-lines in the spectrum of laminar diffraction are seen clearly and sharply defined irrespective of the thickness of the plate or the aperture of the telescope within wide limits, it is suggested that they may be used in preference to Talbot's and Powell's bands for such determinations. AUTHOR.

**237.** *Optical Behaviour of Nitro-Cellulose under Stress.* **E. G. Coker** and **K. C. Chakko.** (Roy. Soc., Phil. Trans. 221. pp. 139–162, Oct. 18, 1920.)—Describes experiments made to determine the relation between the optical and the stress-strain characteristics of nitro-cellulose. It is found that there is no very pronounced elastic limit for this material, and the stress-strain curve is straight up to 1900 lbs. per sq. in. On the other hand the optical retardation of a plate is proportional to the stress up to at least twice this value. The method of obtaining the stress-strain diagram for a specimen by means of spectrum analysis of transmitted light is described in detail, and it is shown that the diagram so obtained agrees well with the results of direct extensometer measurements. It is concluded that, up to twice the elastic limit of stress, the material obeys a linear optical law, and within this range optical determinations of stress distribution may be relied upon. J. W. T. W.

**238.** *Use of "Vacuum Arcs" for Interferometry.* **J. Guild.** (Phys. Soc., Proc. 32. pp. 341–344, Aug., 1920.)—Discusses the relative merits of short and long mercury arcs for this work, and points out that the defect of the former is due to the broadening of the spectrum lines consequent on the high vapour pressure within the lamp. It is shown that by attaching a condensing bulb to the lamp, so as to prevent excessive rise of vapour pressure, the short lamp can be made practically as good as the long one as regards sharpness of lines, while still being of much greater intrinsic brightness. AUTHOR.

**239.** *Application of the Interferometer for Gas Analysis.* **J. D. Edwards.** (Bureau of Standards, Technol. Paper, No. 131. [19 pp.] Washington, 1919.)—Interferometers of the Rayleigh type, designed by Haber and Löwe (Rayleigh-Zeiss) and by Hilger, are differential refractometers. The author outlines the theory of the instruments, gives a table of the refractivity of gases, and describes the calibration and the use of the interferometer. The illustrative examples deal (*a*) with $CO_2$ in air: (1) against normal air as standard; (2) $CO_2$ in air deficient in oxygen against normal air; (3) mixture (2) compared against the residual air previously freed of $CO_2$; (*b*) with flue gas; (*c*) with helium in gas samples obtained during the liquefaction of natural gas. H. B.

**240.** *Focal-Length Equation; Calculation of Paraxial Ray Courses.* **C. W. Woodworth.** (Optical Soc. of America, J. 4. pp. 243–244, Sept., 1920.)—Gives the following equation for the calculation of paraxial ray courses: $j_m = j_{m-1} + i_m\left\{1 - \Sigma(j_\kappa d_\kappa/n_{\kappa+1})\right\}$, where $i_m$ = surface constant = $(n' - n)r$ = $n$/focal length; $j_m$ = lens constant = $n$/focal length; $d$ = separation between the surfaces; $n$ = index of refraction.

The summation above is made from $\kappa = 1$ to $\kappa = m - 1$. The

V.2
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author gives a scheme of arrangement for the convenient calculation of such an optical system as a telescope objective. J. W. T. W.

**241.** *Focal-Length Equation ; Calculation of Portrait Objective.* **J. P. C. Southall.** (Optical Soc. of America, J. 4. pp. 245–248, Sept., 1920.)—Shows that the equation proposed by Woodworth [see preceding Abs.] is practically equivalent to two formulæ of T. Smith, and illustrates the application of these formulæ to the calculation of Petzval's portrait objective. J. W. T. W.

**242.** *Path of Ray through a Prism.* **J. P. C. Southall.** (Optical Soc. of America, J. 4. pp. 283–285, Sept., 1920.)—Gives a geometrical construction for finding the direction of an incident ray which traverses a prism of known refracting angle and index of refraction, and emerges with a given angle of deviation. The corresponding trigonometrical solution is also given. J. W. T. W.

**243.** *Special Cases in Lens Calculation ; Distant Focus Determination.* **C. W. Woodworth.** (Optical Soc. of America, J. 4. pp. 286–293, Sept., 1920.)—Considers the case in lens calculation where it is necessary to determine a distant focus. If the physical data of the refracting element are known to five places of decimals, then a distant focus of 10,000 or upward cannot be determined to more than a single digit with certainty. This may in certain cases produce large inaccuracies in the whole calculation, as for example in the Huyghenian eyepiece. The author therefore proposes a different method of calculation for such cases, based on the determination of the intercepts on a series of reference lines made by the segments of the ray. The scheme of the calculation by this method is illustrated by two examples which show its agreement with the ordinary method, and its superiority in the special case above referred to. J. W. T. W.

**244.** *Ray Path through Symmetrical Optical Instrument.* **J. P. C. Southall.** (Optical Soc. of America, J. 4. pp. 294–299, Sept., 1920.)—Proposes a system of equations for calculating the path of a ray through a series of symmetrical optical surfaces. The method is illustrated by means of a numerical example. J. W. T. W.

**245.** *Striæ in Optical Glass.* **T. T. Smith, A. H. Bennett,** and **G. E. Merritt.** (Bureau of Standards, Bull. 16. pp. 75–91 [Sci. Papers, No. 373], 1920.)—Describes different methods for revealing the presence and importance of striæ in glass. One of these consists of viewing an artificial star through the striated slab, and photographs are given in the paper to illustrate the effect produced. The refractive indices of the striæ, along with those of the surrounding glass, have been measured by the total reflection method, and the striæ are found to have a refractive index differing from that of the surrounding glass by as much as three or four units in the fourth decimal place, the difference being in either direction. The effects of the striæ may be divided into two classes: (*a*) With striæ somewhat out of focus a shadow may be thrown across the field of view. This is likely to give trouble only in cases where they are in focus, or nearly in focus, as with the collector lens in an eyepiece or in the nearer prisms of binoculars. (*b*) The image of a bright point will have streamers of scattered light caused by the striæ. This is of small importance unless the striæ cover a large part of the aperture of the beam of light. In astronomical, and in certain classes of microscopic work, this scattered light would probably be injurious. J. W. T. W.

**246.** *The Cemented Telescope Objective of Barium Crown and Flint.* **I. C. Gardner.** (Optical Soc. of America, J. 4. pp. 274–282, Sept., 1920.)—Harting has shown that the most satisfactory pair of glasses available for a telescope objective of the two-component cemented type is a barium crown, $N_D$. 1·57 to 1·59 and an ordinary flint lying between 1·60 and 1·66 [see Abs. 787 (1899)]. Glasses within this range offer the possibility of correcting simultaneously for chromatic and spherical aberration and the sine condition. The data and graphical representations here given were obtained preliminary to more general and extended calculations, which show the possible combinations of values of the three aberrations which may be obtained by the use of barium crown and flint. A *system of contours* has been constructed which is helpful in the preliminary design of a telescope objective for which the desired values of the aberrations are determined. The characteristics of some typical lenses are tabulated. A. E. G.

**247.** *Spectrophotometry of Flame Arcs.* **I. G. Priest, W. F. Meggers, K. S. Gibson, E. P. T. Tyndall,** and **H. J. McNicholas.** (Bureau of Standards, Technol. Papers, No. 168. [14 pp.], Washington, 1920.)—Amplifies, with a diagram of the apparatus used, the description previously given of this work [see Abs. 1501 (1919)]. The paper also contains photographs of emission spectra of the Speer, Columbia, and Electra carbons burnt in the Sperry arc lamp. J. W. T. W.

**248.** *The Stereoscopic Appearance of Certain Pictures.* **F. W. Edridge-Green.** (Nature, 106. p. 375, Nov. 18, 1920.)—In a picture gallery certain pictures commonly contain objects which "stand out," with stereoscopic effect. Most pictures are correct as regards one eye only, but in the above cases a delineation as seen by the combined retina is presented. The left-hand side of the picture is represented as seen by the left eye, the right-hand side as seen by the right eye. The author has shown that binocular relief is independent of double images and the stimulation of disparate points, provided images are presented to the two retinæ similar to those presented by an object in the field of vision. Thus assume that two stereoscopic pictures are taken with the point of sight at the centre of each and are cut vertically in two. Then if the left half of the left photograph is pasted to the left on cardboard, and the right half of the right-hand photograph an appropriate distance to the right, so that there is no apparent overlapping, a picture in striking relief is obtained by their combination. There is no portion common to both fields, in each case the overlapping portion is combined with white. It seems probable that this is how binocular vision takes place in ordinary circumstances, the right eye dominating the right side of the field and the left eye the left side. J. S. D.

**249.** *Photography of Palimpsests; Fluorescence Photography.* **R. Kögel.** (Preuss. Akad. Wiss. Berlin, Ber. 37. pp. 974–978, 1914.)—Palimpsests are photographed in the ordinary way with the use of colour-filters, and with the aid of ultra-violet light. The third method of the author makes use of fluorescence. Illuminated by the ultra-violet radiations (334 $\mu\mu$) of a quartz-mercury lamp, the parchment fluoresces, but the erased writing remains almost dark, though the old inks used sometimes contained sulphur compounds; chemical alteration of the parchment, greasing, etc., generally does not weaken the contrasts. This fluorescence photography often brings out detail not disclosed by the other methods and has much improved the exploration of old manuscripts. For technical particulars of the method the author refers to Beihefte Zentralbl. f. Bibliothekwesen, XLIV, Leipzig, 1914. H. B.

**250.** *Relation between Photographic Density, Light Intensity, and Exposure Time: A New Formula; the Reciprocity Law.* **F. E. Ross.** (Eastman Kodak Co.'s Research Lab., Comm. No. 93. Optical Soc. of America, J. 4. pp. 255–273, Sept., 1920.)—It can be assumed as a matter of experience that $D = F(T, t \ldots)$ or, density is a function of intensity, time of action, and other variables or parameters. These parameters are so numerous that it is impracticable even to specify them. For the present the reciprocity law will be assumed to hold, namely, that I and $t$ occur in the above formula only in product form. Neglecting all formulæ purporting to take account of the phenomenon of "reversal," four specific formulæ of the above form have been proposed: (*a*) by Abney in 1889; (*b*) by Hurter and Driffield in 1890; (*c*) by Elder in 1893; (*d*) by Channon in 1906. Abney's formula is purely empirical. The other three are based upon differential equations specifying the velocity of light action or the velocity of "infection" of the silver grains, and are to that extent to be considered as theoretical equations. (*a*) The formula of Abney in terms of density is $D = \mu' \log^2 It/i$. This formula can be considered to give a very good representation of the relation between transparency or density, and exposure for the first step in the process, which covers the appearance of the image and its development in strength up to the point where rapid action begins. For certain characters of work making use of weak or so-called under-exposures, Abney's formula applies more accurately than any other which has been proposed. There does not appear, however, to be any theoretical basis for it, at least none has been proposed. It fails to take account of the very obvious fact that there is a limit to the density which can be reached depending upon the amount of silver in the emulsion. (*b*) Elder's equation is $D = D_m(1 - e^{-\kappa It})$ which is derived by integration of the differential equation $dn = \kappa I(N - n)dt$, where $D_m$ is the max. density obtainable, and is a function of the amount of silver in the emulsion; N is the total number of grains per cm.$^2$, to which $D_m$ is proportional; $n$ is the number of grains changed to latent image in the time $t = 0$ to $t = t$; I is the light intensity; $\kappa$ is a parameter depending principally upon grain sensitivity and wave-length of light, and is a measure of the speed of the emulsion. It is concluded that Elder's equation fails in general to explain the characteristics of emulsions. (*c*) The Hurter and Driffield equation is based upon the differential equation $dx = I/b(1 - r)[e^{-\kappa x} - e^{-\kappa a}]dt$, where $dx$ is the number of grains per cm.$^2$ changed to latent image in the time-interval $dt$; $b$ the energy necessary to change one grain; I the light intensity; $r$ the reflection coefficient; $a$ the total number of grains per cm.$^2$ in the emulsion; $\kappa$ is a parameter. (*d*) The equation $D = \rho \log_{10} [O - (O - 1)e^{-\beta It}]$ where $O = e^{-\kappa a}$ is derived from the former. There are three parameters in this equation, one more than in the Elder equation, so that it can be expected to give closer agreement with observed curves than is possible in the case of the latter: and it is found that the Hurter and Driffield formula conforms to actual emulsions considerably better than the Elder formula. The assumption of Hurter and Driffield that the transparency of the $x$-group of grains is given by $\epsilon^{-rx}$ is shown to be incorrect, for it leads to a mathematical inconsistency. Their equations must therefore be considered purely empirical. Channon follows Elder in using the mass-action equation, but takes into account emulsion thickness. The equation to which he is led is not directly integrable. By expansion in series his solution takes the form $D = \gamma\left\{\phi(aE) - \phi(aE\delta)\right\}$, where $\gamma$, $a$, and $\delta$ are parameters, E is exposure and $\phi$ a functional form as follows: $\phi n = n - n^2/(2 \times 2!) + n^3/(3 \times 3!) - n^4/(4 \times 4!) + \dots$. Agreement with observed curves is of the same order as the Hurter and Driffield formula. Theoretically it is well grounded, but fails to take account of varying sensitivity of grain.

*Development of a New Formula.*—On account of the general applicability of the mass-action equation to certain classes of chemical and physical problems, it seems worth while to apply it to the present problem in a manner more circumspect and cautious than has hitherto been done. It will be assumed that the law applies only to the case of a single layer of grains, which therefore individually receive equal exposures. Actual emulsions are composed of grains lying in layers, many layers thick, and very often of grains of varying sensitiveness. Obviously many formulæ can be constructed, depending upon the particular assumptions of the following classes: (*a*) Relative frequency of grains of varying size. (*b*) Relative sensitivity of grains of varying size. (*c*) Variation of grain-sensitivity with light intensity and wave-length for each class of grains. (*d*) Ratio of inert to active grains, depending on grain size. (*e*) Number of layers of silver halide. (*f*) Opacity of the emulsion and its variation with wave-length. This is not an exhaustive list of the factors which must be considered in developing the theory of the subjects. It would be unprofitable in the absence of data on the controlling factors enumerated above to develop a formula on any but the simplest assumptions. These are: (1) All the grains in an emulsion divisible into $n$ groups, each group as a whole obeying the mass-action law. (2) The silver mass the same for each group. (3) The sensitivity factor of the groups arrangeable in geometrical progression. This takes account of the factors of (*a*) true sensitivity differences, (*b*) apparent sensitivity differences, due to the thickness of the emulsion. This equivalence is possible on account of the reciprocal equivalence of $\kappa$ and I in the Elder formula. With these assumptions the equation connecting density with exposure can easily be derived. Calling $d_m$ the max. density (for infinite exposure), $\kappa$ the sensitivity factor, $r$ the common ratio of the sensitiveness of the various groups, the equation becomes

$$D = d_m\left[1 - 1/n \sum_{s=0}^{s=n-1} \epsilon^{-\kappa r^s It}\right].$$

It is noticed that for increasing values of $n$ the contrast or gamma becomes less and the straight-line portion longer. The "toe" diminishes with $n$, a characteristic not to be found in the case of the Hurter and Driffield equation.

*The reciprocity law* is considered in some detail. If Kron's results are correct, the reciprocity law holds with considerable exactness between the intensities of one metre-Hefner and 0·001 metre-Hefner, it breaking down only for higher and lower intensities. Furthermore, for all higher intensities, the reciprocity law holds with more exactness than Schwarzschild's. If the latter law is correct, the former does not hold for any value of the intensity, the error being the same in percentage amount for all intensities. Study of characteristic curves obtained under varying conditions as to time and intensity will give a direct indication of the law relating photographic effect to exposure-time and intensity.

A. E. G.

**251.** *Optical Rotation, Optical Isomerism, and the Ring-Electron.* **H. S. Allen.** (Phil. Mag. 40. pp. 426–439, Oct., 1920.)—It is assumed that the electron, in addition to its electrostatic action, behaves like a current circulating in a closed ring, and consequently acts as a small magnet [Abs. 470 (1919)]. Such a ring-electron vibrating in a linear path takes the place of an ordinary electron moving in a spiral path as postulated by Drude. It is shown that rotation of the plane of polarisation will result, and an expression is found for the amount of rotation per unit length. Employing the theory of atomic structure due to Lewis and Langmuir [Abs. 991 (1919)], a graphical representation may be obtained for dextro- and lævo-rotatory forms of a compound. The experimental facts with regard to optical activity are in good agreement with the theory put forward, which may be applied not merely to carbon compounds, but to any compound containing an asymmetric atom.

A. W.

**252.** *X-ray Spectra of Tungsten.* **W. Duane** and **R. A. Patterson.** (Phys. Rev. 16. pp. 526–539, Dec., 1920. Paper read before the Am. Phys. Soc., Feb., 1920.)—*Critical Absorption and Emission Wave-lengths in K and L Series.*—This paper describes accurate measurements of the critical absorption wave-lengths associated with the K and the L series, and also of the wave-lengths of most of the emission lines in the L series. The measurements were made by means of a new ionisation spectrometer, similar to the one previously described. A high-tension storage battery supplied the current through the X-ray tube, the voltage and current being kept constant by the procedure indicated in the reference. To eliminate errors due to the penetration of the rays into the crystal and to lack of exact adjustment between the axis of rotation of the crystal and the *effective* reflecting plane, etc., the authors employed the third method mentioned in the article referred to above. In this method two slits between the X-ray tube and the spectrometer define the width of the beam of X-rays that strikes the crystal, and the slit in front of the ionisation chamber has sufficient breadth to allow the entire reflected beam to enter the chamber. With this arrangement of slits the angle through which the crystal turns (not the angle made by the *reflected* beam of rays with the zero of the instrument) measures the glancing angle that is used in the formula to calculate the wave-length.

*Mean Values of the Wave-lengths measured in Spectra of the 1st, 2nd, and 3rd Orders.*—The following table contains the weighted mean values of the wave-lengths obtained from measurements in spectra of the 1st, 2nd, and 3rd orders, together with an estimate of the precision of the measurements. To estimate the *absolute* accuracy of the data the errors in the value of the grating constant of the calcite crystal used must be taken into account. These add up to about 0·07 %. In the text the values of the emission wave-lengths obtained by this ionisation method are compared with those measurements of the same lines by photographic methods in which special procedures have been employed to minimise the effects of the above-mentioned errors.

### X-RAY SPECTRA OF TUNGSTEN.

Grating Constant for Calcite $2a = (6\cdot056 \pm 0\cdot004) \times 10^{-8}$ cm.

Critical Absorption Wave-Lengths, $\lambda \times 10^8$ cm.

| $K\alpha$ | $L\alpha_1$ | $L\alpha_2$ | $L\alpha_3$ | |
|---|---|---|---|---|
| $0\cdot17806 \pm 7$ | $1\cdot2136 \pm 1$ | $1\cdot0726 \pm 5$ | $1\cdot024 \pm 3$ | |

Emission Wave-Lengths, $\lambda \times 10^8$ cm.

| | | | | |
|---|---|---|---|---|
| $K\alpha_2$ | $K\alpha_1$ | $K\beta$ | $K\gamma$ | |
| $0\cdot21341 \pm 3$ | $0\cdot20860 \pm 4$ | $0\cdot18420 \pm 3$ | $0\cdot17901 \pm 6$ | |
| $Ll$ | $L\alpha_2$ | $L\alpha_1$ | $L\eta$ | |
| $1\cdot6756 \pm 10$ | $1\cdot4839 \pm 3$ | $1\cdot47306 \pm 11$ | $1\cdot4176 \pm 7$ | |
| $L\beta_4$ | $L\beta_1$ | $L\beta_3$ | $L\beta_2$ | $L\beta_5$ |
| $1\cdot2985 \pm 4$ | $1\cdot27892 \pm 9$ | $1\cdot2601 \pm 3$ | $1\cdot24193 \pm 12$ | $1\cdot2040 \pm 7$ |
| $L\gamma_1$ | $L\gamma_2$ | $L\gamma_3$ | $L\gamma_4$ | |
| $1\cdot09608 \pm 7$ | $1\cdot0655 \pm 4$ | $1\cdot0596 \pm 3$ | $1\cdot0261 \pm 6$ | |

The K emission wave-lengths have been taken from a paper by Stenström and one of the authors.

*Relative Intensity of the Lines.*—The ionisation spectrometer furnishes the best method of estimating the relative intensity, the relative breadth, etc., of emission and absorption lines, provided that they are so near together that the effect of absorption by the tube, etc., may be neglected or corrected for. The numerous curves in the text give a good idea of the relative intensity, etc., of the lines.

*The Differences between the K and L Absorption Frequencies Equal the Kα Emission Frequencies in Each Case to within the Errors of Measurement.*—The object of the research has been to obtain accurate values of both the absorption and the emission wave-lengths measured under the same experimental conditions. This becomes particularly important in testing theoretical laws and relations. According to the theory of the mechanism of radiation based on the Rutherford-Bohr atomic model the K critical absorption frequency should be complex, if, as Sommerfeld assumes, some atoms contain elliptic orbits and other atoms of the same chemical element contain circular orbits. Further, the difference between the *average* K critical absorption frequency and one of the L critical absorption frequencies should not exactly equal the frequency of one of the Kα emission lines. As a matter of fact the authors have not observed a doubling of the K absorption frequency, and their new measurements verify the results obtained by Duane and Shimizu. The difference between the K absorption frequency and one of the L absorption frequencies equals the frequency of one of the $K\alpha$ emission lines in each case to within the errors of measurement. Hence, if the effect due to different kinds of tungsten atoms exists at all, it is too small to be detected, at least for chemical elements of high atomic numbers.

*Test of Sommerfeld's Formula for the Frequency Interval of the L Doublet.*—A. Sommerfeld has deduced from Bohr's theory an expression for the frequency interval of the L series doublet by making an interesting application of one of the equations in the quantum theory, which enables him to calculate the eccentricity of an elliptic orbit. The expression contains one undetermined constant, to which he gives the value 3·63. This value he obtains by using the published wave-lengths of the lines in the L series of a great many chemical elements. Although there is some difficulty in giving a physical interpretation to the theory, yet, when the constant is substituted in the formula, the frequency difference of the L series doublet in the tungsten spectrum is obtained to within less than 1 % of the value the authors found by experiment.
AUTHORS.

**253.** *Effect of Fluorescence and Dissociation on the Ionising Potential of Iodine Vapour.* **H. D. Smith** and **K. T. Compton.** (Phys. Rev. 16. pp. 501–513, Dec., 1920.)—*Fluorescence and Ionisation.*—When fluorescing under the influence of the mercury green line, *iodine vapour* shows weak ionisation at a potential about 2·6 volts less than the normal ionising potential. This is attributed to ionisation by impact against molecules whose electrons have been displaced by absorption of the exciting radiant energy.

*Dissociation and Ionisation.*—Another weak ionisation always observed at about 1·5 volts less than the normal ionising potential was attributed to ionisation of atomic iodine, present as result of the dissociating action of the hot filament. This was verified by experiments in a pyrex glass apparatus at such high temperatures as to cause a high percentage of dissociation, when it was found that this new type of ionisation was very intense.

*The observed ionising potentials were*: 6·8 volts, due to fluorescing molecules; 8 volts, due to iodine atoms; 9·4 volts due to iodine molecules. The difference between the first and last values corresponds roughly to the *quantum* of absorbed radiant energy, while the difference between the two latter values agrees accurately with the *heat of dissociation* of iodine molecules.
AUTHORS.

**254.** *X-ray Fluorescence of Certain Organic Compounds, notably Sodium Bromide.* **H. S. Newcomer.** (Am. Chem. Soc., J. 42. pp. 1997–2007, Oct., 1920.)—An extended search for a substance which might be available in biological research (relatively soluble), and at the same time be capable of emitting fluorescent rays in the mid-ultra-violet region of the spectrum under the influence of X-rays, has revealed only sodium bromide as possessing these qualities. Many organic compounds fluoresce brightly in the visible region of the spectrum, and a moderate number of them give fluorescence which is capable of blackening a photographic plate.

It has been shown that there are solids, liquids, gases, and certain solutions which fluoresce. The phenomenon is not limited to any physical state. The nature of the fluorescence excited in any material, both as to intensity and quality, is independent of the quality of the exciting X-rays and dependent on energy alone. A. B. W.

**255.** *Peculiar Effect Produced by $\alpha$-Ray Bombardment.* **E. Mühlestein.** (Arch. des Sciences, 2. pp. 423–424, Sept.–Oct., 1920. Paper read before the Soc. Suisse de Physique.)—In the course of a series of experiments on the photographic effects produced by $\alpha$-rays, the author has observed curious deformations in the photographic layer. As a source of $\alpha$-rays, small copper plates coated with a very active layer of polonium were employed, these discs being placed perpendicular to the photographic film. In the immediate neighbourhood of the small active surface, in the region of most intense bombardment, there appears on the plate (developed, fixed, and dried) a depression resembling the imprint of finger nails: the hollow, forming an oval arc, having a depth nearly half the thickness of the film. Attempts to explain the formation of this depression on the grounds of chemical decomposition of silver-gelatine-bromide by the bombardment of $\alpha$-particles were unsatisfactory, only a small fraction of the effect being traced to this cause. It appeared, therefore, that the depressions might be due to some direct action of the $\alpha$-rays on the gelatine. Experiments on pure gelatine films soon verified this, the depressions being quite well marked as before. For example, with a gelatine layer $46\ \mu$ thick the depth of the depression after bombardment, *subsequent soaking in water* and drying, was about $22\mu$, nearly half the thickness of the gelatine layer. The effect is not directly mechanical, since the depression is not observed before the film is soaked in water. After water treatment and subsequent drying, however, the depression remains permanent.

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The author suggests that the effect may be due to some change in the molecular structure of the gelatine, but he reserves a decision until further experiments have been made. A. B. W.

**256.** *Short-Wave Arc Spectra* in Vacuo *and Spark Spectra in Helium of Various Elements* (*Sb, Bi, Ca, Pb, Se*). **J. C. McLennan, J. F. T. Young,** and **H. J. C. Ireton.** (Roy. Soc., Proc. 98. pp. 95–108, Oct. 1, 1920.)—The spark spectra studied, and all but one arc spectrum, were obtained with the fluorite spectrograph previously used by McLennan, Ainslie, and Fuller (Abs. 587 (1919)]. Full details are given of the spark and arc chamber. Photographs were taken of the vacuum arc spectra of antimony, bismuth, calcium, magnesium, selenium, silver, and copper, and of the spark spectra in helium of antimony, bismuth, aluminium, cadmium, lead, magnesium, thallium, and tin, the spectral region of the investigations being below $\lambda 1850$ Å.U. Wave-length tables are given for each of the above spectra. The measurements of the arc spectra of Sb, Bi, Ca, and Se, and the spark spectra of Sb and Pb, appear to be the first recorded for these substances in this region. The results obtained with the vacuum grating spectrograph have led to the extension of the vacuum-arc spectrum of copper to about $\lambda 1216$ Å.U. [See Abs. 434 (1919) and 1660 (1920)]. A. W.

**257.** *Helium–Hydrogen Series Constants.* **H. Bell.** (Phil. Mag. 40. pp. 489–494, Oct., 1920.)—A discussion of the Bohr-Sommerfeld theory for the helium and hydrogen series lines and of Paschen's measurements [Abs. 48 (1917)] leads to the conclusion that Paschen's values have been over-corrected. Various considerations tend to show that the value of N for helium should be 109677·9 instead of Paschen's value 109677·691 ± 0·6. Curtis gave as a mean of the various formulæ tried 109678·3. Interferometer measurements are needed for the earlier hydrogen lines. [See Abs. 1042 (1915).] A. W.

**258.** *Spark Spectra of Various Elements (Si, Te, Mo, Zr) in Helium in the Extreme Ultra-Violet.* **J. C. McLennan** and **A. C. Lewis.** (Roy. Soc., Proc. 98. pp. 109–114, Oct. 1, 1920.)—The fluorite spectrograph previously described [Abs. 587 (1919)] was used in the earlier part of the work, but it was found unsuitable for rapid work. The instrument was completely re-designed, and the new model is described. It was used to investigate the extreme ultra-violet spectra of silicon, tellurium, molybdenum, and zirconium. A table is given of wave-lengths of the lines observed between λ1634 and λ1854. A. W.

**259.** *Vacuum Grating Spectroscopy; Helium Spectrum.* **J. C. McLennan.** (Roy. Soc., Proc. 98. pp. 114–123, Oct. 1, 1920.)—A description has already been given [Abs. 565 (1919)] of a vacuum grating spectrograph used for studying the vacuum arc spectra of a few of the elements. The spectrograph has been re-designed, and in the new instrument provision has been made for removing the exuded gases, for using a grating of any size, and for arranging its carrier and controls so that adjustments could readily and easily be made. A detailed description of the instrument, with numerous diagrams, is given.

*Helium Spectrum.*—A special study was made of the spectrum obtainable from an arc in helium between tungsten terminals, in order to pick out the lines which could be definitely assigned to He itself. For this a special arc chamber was used, filled with purified He at a pressure of 30 to 40 cm. of mercury. A small heating coil was used to start the arc. At the pressures used it was found easy to establish and maintain for hours arcs in helium with distances of 5 or 6 mm. between the tungsten beads. The p.d. across the terminals was about 45 volts and the current 4·6 amps. A table is given of wave-lengths from λ1988 to λ1025, and it appears from Lyman's results that most of the lines observed were due to hydrogen. In order to obtain the spectrum of helium, very special precautions will have to be taken to remove all traces of hydrogen from the spectrograph, and to obtain the shortest wave-lengths it would be necessary so to arrange matters that the potential drop across the arc was considerably increased. A. W.

**260.** *Absorption of Light by Vapours of Selenium, Tellurium, Mercury, Zinc, Cadmium, Phosphorus, Arsenic, and Bismuth.* **J. J. Dobbie** and **J. J. Fox.** (Roy. Soc., Proc. 98. pp. 147–153, Nov. 3, 1920.)—The apparatus and arrangements employed in the research were similar to those described in a previous paper [Abs. 1105 (1919)]. Results are given for Se and Te; Hg, Zn, and Cd; P, As, and Sb.

*Selenium and Tellurium.*—With Se there is an increase in the absorption from 510° C. to about 650° C., from which point it diminishes up to 850° C. Above 850° C. no further change is observed even at the highest temperature reached, 1350° C. The vapour becomes pale yellow almost suddenly at 600° C.; between 600° and 700° C. it is deep orange, and at this temperature is almost opaque to the rays from a Nernst lamp. About 850° C. the colour again becomes pale yellow, and no further change takes place at higher temperatures. The point of max. absorption of Se lies very near that of S, viz., 650° C., and the vapour density at that temperature corresponds with an average value of 3 atoms per molecule. Both elements become wholly diatomic at about 900° C. The behaviour of Te is very similar to that of Se, but the temperatures are higher. The general absorption increases with rise of temperature up to about 1250° C., after which it diminishes up to 1350°. At 1250° the constitution of its vapour appears to be analogous to that of S and Se at 650°. A table is given of the wave-lengths of the absorption bands for Se and Te.

*Mercury, Zinc, and Cadmium.*—Mercury vapour showed very little absorption at any temperature. Cadmium, like mercury, shows no general absorption at any temperature, but a small number of sharply defined absorption bands occur in the ultra-violet; (*a*) A very fine sharp band at λ3793, which appears at a temperature of 900° C. (*b*) A fine band at λ3260 or λ3261, showing first at about 600° C., which widens as the temperature is raised; the widened band is sharp on the red side, but shaded off towards the ultra-violet. (*c*) A diffuse band at λ3186, showing first at 900° C. (*d*) Two sharp bands at λ36544, λ3699 appearing about 1200°. (*e*) λ3061, appearing at 1000° C., and λ3382, appearing at 1100°. Zinc behaves generally in the same way as mercury, but at 110° C. four very sharp faint bands appear at λ3699, λ3654, λ3384, and λ3284.

*Phosphorus, Arsenic, and Antimony.*—These three elements behave in a similar manner, the absorption increasing with increase of temperature. No absorption bands or indications of any kind of selective absorption were observed in the elements of this group. Typical photographs are reproduced. A. W.

**261.** *Effect of Temperature upon the Infra-red Absorption of Certain Glasses.* **G. E. Grantham.** (Phys. Rev. 16. pp. 565–574, Dec., 1920.)—*Change of the Infra-red Transmission of Glass with Rise of Temperature.*—K. S. Gibson has studied the effect of temperature rise upon the absorption spectra of certain glasses in the visible region. He found a shift toward the longer wave-lengths and a decrease in transmission. The infra-red transmission (0·6 μ to 4·0 μ) of the same specimens has been studied at 80°, 307°, and 440° C. Rise of temperature increases the transmission in the region of an absorption band. There is a shift of the transmission bands toward the longer wave-lengths. The same results are obtained whether a series of ascending or a series of descending temperatures be observed. AUTHOR.

**262.** *Effect of a Magnetic Field on the Intensity of Spectrum Lines for Mercury, Helium, and Neon.* **H. P. Waran.** (Cambridge Phil. Soc., Proc. 20. pp. 45–49, Sept., 1920.)—*Mercury.*—When the capillary portion of a mercury discharge tube was placed between the poles of a magnet and subjected to a field of about 5000 c.g.s. units, the light was observed to suffer a change in intensity and also in colour opposite the pole-pieces. A spectroscopic examination showed the existence of some selective changes in the spectrum in addition to the increased brilliancy of the general spectrum. The changes were found to vary considerably with the pressure; at a low pressure the tube showed little change visually,

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but greater changes in the general spectrum. With a mercury tube containing a trace of air at very low pressure the principal mercury lines, λ5790·7, 5769·6, 5460·7, 4916·0, 4358·3, were given together with the hydrogen lines, λ6563, 4861·5, and 4340·7. On applying the magnetic field marked changes were observed, including a *new set of lines at* λ5426, 5670, 5872, and 5889, and a *very strong red line at* λ6152. The latter line was invisible under ordinary conditions, but showed up brilliantly in the magnetic field. At still lower pressure and with increased current, four faint lines appeared at λ6234, 6152, 6123, and 6072. In addition to these changes there were also many minor changes.

*Helium.*—The effect on a helium tube (which contained hydrogen and a slight trace of mercury vapour as impurities) was to enhance the He lines very considerably, leaving the hydrogen lines practically unaffected or even slightly reduced in intensity. In later experiments the He was contained in a separate tube from which any small quantity could be introduced into the discharge tube. At 1 mm. pressure the addition of a small trace of He produced no perceptible effect on the spectrum of residual air, but on switching on the magnetic field the helium lines flashed out prominently and disappeared again when the field was switched off. With a greater percentage of helium the He lines were visible without the magnetic field, but a great enhancement of these lines was observed with the field on, and a dense *new line at* λ4933·4, which has not yet been definitely identified.

*Neon.*—The effect with neon was similar to that observed with helium, the Ne lines being very considerably enhanced.

Experiments lead to the *conclusion* that in a mixture of the monatomic and diatomic gases, the monatomic gases alone seem to be selectively affected in some way, resulting in a considerable enhancement of their spectrum lines. The nature of the phenomena observed is not yet understood, but it does not seem that the changes in intensity can be attributed to changes in the current through the tube, since the effect of the field was to decrease the current by about 20 to 30 %. A. W.

## RADIO-ACTIVITY.

**263.** *Chemical Reaction Caused by α-Radiations.* **E. Wourtzel.** (J. de Physique et le Radium, 1. pp. 77–96, Sept., 1920.)—Considerations based upon the author's experiments [Abs. 632 (1920)] and upon experiments by Usher, Taylor, Duane, Scheuer, and others. The chemical effect of α-rays is not equivalent to the ionisation, and may exceed the latter; it is a function only of the velocity of the α-particle and of the number of collisions with gas molecules, and does not otherwise depend upon the pressure. This function varies approximately in the same way in gases which differ as much as $H_2S$ and $NH_3$. The maximum chemical effect and the ratio $M_\infty/N_\infty$ can be calculated by a formula deduced from the experiments of Duane and Laborde; the formula for M/N (M=number of molecules decomposed per Curie-second, N=number of pairs of ions) agrees with that of Lind. In gas mixtures the primary reaction is a function only of the collisions with the molecules which are susceptible of decomposition; at sufficiently high temperature this number approaches the number of molecules hit, while the kinetic effect of the hit molecules is of secondary order. The primary action of the α-rays is to liberate atoms or atomic groups of high activity. The thermal coefficient of radio-chemical reactions is always very small ; it may be negative, and it approaches zero when the number of decomposed molecules comes up to the number of molecules hit. The primary and principal action of the α-rays is determined by the chemical affinities in the interior of the molecules, that is to say, upon the heat necessary to effect that decomposition, and not upon the heat of the final transformation of the system. **H. B.**

**264.** *Radium Content of the Rocks of the Loetschberg Tunnel.* **J. H. J. Poole.** (Phil. Mag. 40. pp. 466–471, Oct., 1920.)—The mean radium content for all rocks examined (82 specimens) is 2·4 × $10^{-12}$ gm. per gm. ; for all schists, 2·4 × $10^{-12}$ gm. per gm. The discrepancy between the mean of these, 2·3, and the figure 2·7 obtained by Joly from a composite rock of 63 granites, is much reduced if one specimen of abnormally low value, 1·3 × $10^{-12}$, is neglected. For details as to the contents of the individual specimens the tables in the original should be consulted. **L. H. W.**

**265.** *Rutherford's Work on the Collision of α-Particles with Light Atoms.* **W. Rihl.** (Zeits. f. Techn. Physik, 1. 8. pp. 159–165, 1920.)—This contribution is mainly a summary of Rutherford's recent work as set forth in four papers by him in 1919 [Abs. 912 (1919)].

## HEAT.

**266.** *Thermoelectric Apparatus for Measurement of Radiation.* **W. Voege.** (Phys. Zeits. 21. pp. 288–296, June 1, 1920.)—Describes various forms of thermopile used for the detection of radiation concentrated by means of a parabolic mirror on to the apparatus situated at its focus. The instrument was designed during the war for use with signalling apparatus employing invisible in place of visible radiation. The chief characteristics desired were (*a*) high thermoelectric potential with smallest possible internal resistance, (*b*) fullest use of the radiation concentrated at the focus of the mirror, (*c*) small lag, and (*d*) robustness as regards mechanical shock. The form of thermo-element employed was one of bismuth–iron *in vacuo*, and in the final apparatus ten such elements were used, having an area of 40 mm.$^2$ and an internal resistance of 38 ohms. A 16-c.p. carbon lamp at a distance of 2 m. gave a deflection, with this instrument of 49 deg. on a galvanometer with resistance 50 ohms and constant $1^\circ = 6 \times 10^{-8}$ amp. J. W. T. W.

**267.** *Measurement of Physical Properties at High Temperatures; Apparatus for Tests on Refractories.* **A. G. Tarrant.** (Faraday Soc., Trans. 15. pp. 83–94; Disc., 94–97, June, 1920. Engineering, 108. p. 875, Dec. 26, 1919.)—A description of apparatus for tests in works' laboratories of refractory materials, especially crucible graphite containing clay substance. For the thermal expansion test the rod specimen is placed within a vertical tubular furnace; a plunger rod of graphite rests on the specimen, the knife-edge of which bears outside the furnace against a lever. In the strength test at temperatures up to 1800° C. the test rod, 30 in. long, is placed within a liner of gas carbon in a tubular furnace of spirally-cut Acheson graphite. To fix the upper clamp a shoulder is formed on the rod by wrapping a linen bandage, wet with sodium silicate, round the rod and air-drying this wad. Cracks in the graphite spiral are mended by brushing the fracture with a paste consisting of graphite and synthetic resin (phenol and formaldehyde), while the current is flowing through the spiral; some spirals had four times been repaired in this way. The high-temperature strength test proves frequently to be of less importance than the low-temperature test, which is performed by shaping a pat of the material as in cement testing; the pat (of 8-shape) is air-dried and soft-burned. The apparatus for thermal conductivity tests had not yet assumed final shape. The *discussion*, by **E. A. Coad-Pryor** and others, referred to the similar work done at the National Physical Laboratory and to the various expedients used by Tarrant in overcoming experimental difficulties. H. B.

**268.** *Thermal Conductivity of some Solid Insulators.* **J. R. Clarke.** (Phil. Mag. 40. pp. 502–504, Oct., 1920.)—Thornton, from an inspection of the physical constants of some solid heat insulators, has observed that $k = E\rho$, where $k$ is the thermal conductivity, E the elasticity, and $\rho$ the density of the substance [Abs. 393 (1920)]. Among the substances which showed the agreement were various kinds of glass. The data used were obtained from tables, and it is not certain that the constants in the different tables refer to specimens of the same composition. It is desirable to ascertain if the relation holds good when the constants are determined using the same glass. Optical glass is suitable, for precautions are taken to ensure that the composition is always the same. The author takes the constants as determined by various observers for Jena glass (Nos. 19 to 33 and 38) and shows that the relation $k = E\rho$ is not approximately valid, nor even a relation of the type $k = E\rho^n$.

Although the empirical relation suggested by Thornton does not hold, the statement that the thermal conductivity increases with the elasticity and with the density seems to be approximately correct, except for heavy glasses, and may be of some use as a rough guide when seeking for a heat insulator or for a good conducting glass. T. H.

**269.** *Melting-Point Methods at High Temperatures.* **L. I. Dana** and **P. D. Foote.** (Faraday Soc., Trans. 15. pp. 186–217, June, 1920.)—Describes the methods in use at the Bureau of Standards and the Geophysical Laboratory, especially thermoelectric pyrometers for pure substances, metals and alloys, both in precision and technical work, and further optical pyrometers; the use of resistance thermometers and other methods is also mentioned with special regard to refractory materials. H. B.

**270.** *The Specific Heat of Ammonia; "Point" Method for Determinations at Higher Temperatures.* **H. A. Babcock.** (Am. Acad., Proc. 55. pp. 325–409, Oct., 1920.)—The investigation described in this paper is a continuation of measurements on the thermodynamic properties of ammonia made at the Massachusetts Institute of Technology in 1912–13. The work was divided into two parts, the equation of state for ammonia being determined by Keyes and Brownlee, while Keyes and the author made measurements of the specific heat. The mean specific heat capacity of liquid ammonia was determined by a parallel method of mixtures, using water as a reference substance, between 0°–20° C. and between 20°–50° C. Realising the unsuitability of this method for higher temperatures, where the specific heat varies rapidly with temperature, Keyes devised a "point" method which gave the mean specific heat over very small temperature ranges. By this method some rough measurements were made between 25°–95° C., and the investigation now described is an elaboration of this last method. Section II describes the experimental method by which the specific heat capacity at constant volume, of a mixture of ammonia, liquid and vapour has been determined over a temperature range from 30° to 125° C., by heating the ammonia with measured amounts of electrical energy through temperature ranges of about 1 deg. C., from various initial temperatures. The calorimeter contains the calorimetric fluid, a heater, a Pt-resistance thermometer, and a sealed tube enclosing the ammonia. The mean heat capacity of the entire apparatus over the temperature interval is obtained by dividing the energy input by the temperature change produced by this energy. Since the rate of change of heat capacity does not vary appreciably during a heating of one degree, the value obtained is taken as the heat capacity at the mean temperature of the experiment. The heat capacity of the system was measured first when the apparatus was loaded with ammonia, and again when empty. At any particular temperature the difference of these heat capacities is the heat capacity of ammonia, whose specific heat can then be computed. Corrections are discussed.

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Section III describes the *apparatus* in detail and occupies 8 pages. The calorimeter was a steel tube containing mercury, in which were immersed the ammonia container, etc., the whole being jacketed in a Dewar vacuum flask, enclosed in a vessel and totally submerged in an oil-bath whose temperature could be controlled. A special calorimetric Wheatstone bridge was used in connection with the Pt-resistance thermometer. A special method of computing the calorimetric curves and the cooling correction was developed. Section IV deals with the laboratory equations and methods of measurement, including calibration of the different apparatus employed. In Section V, which occupies 41 pages of the paper, all the original observations are given, and such other data as were used in the computation of the results or were necessary to determine the precision of these measurements. Section VI contains the experimental results in tabular and graphic form. These consist of two curves, giving the heat capacities of the apparatus when loaded with ammonia, and when empty, as a function of the temperature. Equations are given in Section VII, which permit the computation of any other specific heat in the liquid–vapour region, or on the boundary of that region, from the experimentally determined values of the specific heat at constant specific volume. This section also contains the Keyes-Brownlee data for ammonia, also a comparison with previous results. A critical survey of the work, including a comparison of values of the saturation specific heat of the liquid, occupies Section VIII. The conditions met with at higher temperatures determined the design of the apparatus and so placed a limit on the accuracy obtainable. At the highest temperature reached, 125° C., the pressure in the container was about 100 atmos., which necessitated a rather massive container; this in turn gave rise to temperature lag difficulties. Further, in the region near the critical temperature, where the specific heat is increasing very rapidly with increasing temperature, it was imperative that the ammonia be heated only over small temperature ranges, so that the mean value of the specific heat determined in this way would be very closely the actual value of the specific heat at the mean temperature of the experiment. These two requirements seriously affect the precision attainable with this method. Probably the principal source of error lies in the fact that the parts of the calorimetric apparatus do not change temperature at the same rate during the heating, and that considerable time must elapse after the heating current is cut off before these temperature differences are equalised, which makes the equalised temperature at the time the switch is opened difficult to determine. Newton's law of cooling for temperature differences of 4 or 5 deg. between the calorimeter and the bath was found to be inexact, although the error involved by its adoption was found to be much smaller than that due to uncertainty in the final equalised temperature. A change of 10 % in the stirring motor voltage was found to be necessary before the slope of the temperature curve was changed by a measurable amount.

*Accuracy of Results.*—As the measurements were being made and computed, it was realised that the accuracy attainable by this method was less than had been hoped for, the average deviation being of the order of 0·5 %. It is believed, however, that the method is the only one so far proposed which is adapted to measurements of specific heat in the region under investigation. An Appendix contains a useful summary of the notation employed. H. H. Ho.

**271.** *Specific Heat of Saturated Vapours and the Entropy-Temperature Diagrams of Certain Fluids.* **J. A. Ewing.** (Phil. Mag. 40. pp. 501-502, Oct., 1920.)—The author thanks A. W. Porter for his comments on a recent paper [see Abs. 1439 and 1440 (1920)] and for his reference to the work of Mathias on sulphurous acid. He now explains one point which was put too briefly in the above paper. The entropy of the liquid, $\phi_w$, is of course $\int K_w d\phi_w/T$, as follows from $K_w = T d\phi_w/dT$. But in general there is no direct experimental knowledge of $K_w$, whereas in certain fluids the specific heat at constant pressure, $C_p$, is known (approximately and through a limited range). If the liquid be supposed initially at 0°, and at a pressure $P_t$ equal to the saturation pressure for temperature $t$, the increase of entropy while the liquid is heated to its saturation temperature under that pressure is $\int[t, 0]C_p \, . \, dT/T$. Using this expression, known values of $C_p$ may be applied to calculate the increase of entropy in the process of heating the liquid. This integral gives the quantity $\phi_w - [\phi_w]_0$, where $[\phi_w]_0$ is the entropy of the liquid at temperature 0° and pressure $P_t$. For the purpose indicated in the paper, namely, to obtain the first approximation to the entropy-temperature diagram, the small quantity $[\phi_w]_0$ was ignored. Each constant-pressure line in the diagram, along which the heating of the liquid was supposed to take place, was treated as practically coinciding with the liquid boundary curve: it actually lies slightly to the left of that curve until the saturation temperature is reached. An error in the expression for $K_w$ is corrected, viz. $K_w = C_v + T(\partial p/\partial T)_v \, . \, ds/dT$. H. H. Ho.

**272.** *Convective Cooling and the Theory of Dimensions.* **L. F. Richardson.** (Phys. Soc., Proc. 32. pp. 405-409; Disc., 409, Aug., 1920.)—The paper consists of an application of the "Principle of Similitude" [Rayleigh, Abs. 533 (1915)] to the loss of heat from hot wires, thermometer bulbs, etc. An equation is obtained which does not involve the dimensions of the bodies and which agrees with the formulæ of King for fine wires and of Hill for thermometer bulbs. AUTHOR.

**273.** *Dilatation and Compressibility of Liquid Carbonic Acid.* **C. F. Jenkin.** (Roy. Soc., Proc. 98. pp. 170-182, Nov. 3, 1920.)—In a former paper [see Abs. 1849 (1913)] it was pointed out that, in order to determine a starting-point for drawing the $\theta\phi$ and $I\phi$ diagrams for $CO_2$, it was necessary to know the coefficient of expansion of the liquid at constant pressure. The results of a series of measurements on the dilatation and elasticity of the liquid were given, but it was pointed out that the results obtained were not in agreement amongst themselves, though sufficiently accurate for the purpose for which they were needed. A *new series of measurements* has now been completed, and these are described in the present paper. The dilatometer used is very fully described, together with the arrangements of the apparatus for charging and regulating the pressure within. The various calibrations are next discussed, and then the method of making the tests. The observations at low temperatures were smoothly and easily made, but at the high temperatures were more difficult. As it nears the critical point, the liquid becomes both excessively elastic and excessively sensitive to temperature changes—at the critical point the coefficient of expansion is infinite. One result of this is that, each time the pressure is lowered to adjust it to a new value, the liquid expands and, in so doing, cools itself, thus throwing the temperature adjustment out. As the temperature is raised again, the liquid expands, and the pressure has in consequence to be slightly re-adjusted. The reduction of results receives careful description, while possible errors are exhaustively examined. Three sets of tables accompanied by curves summarise the results obtained. **H. H. Ho.**

**274.** *Heat of Evaporation of Water; Dependence upon Temperature.* **F. Henning.** (Zeits. f. Physik, 2. 2. pp. 197–199, 1920.)—Commenting upon v. Steinwehr's paper [Abs. 1443 (1920)], the author remarks that theoretically the temperature coefficient $r$ of the heat of evaporation can be deduced only for the critical point at which $dr/dT = -\infty$. Within the range of small pressures, however, the relation between the specific heats in the liquid and the vapour states admits of calculating $r$ from known data. Assuming that the specific volumes of the vapour $v_1$ and of the liquid $v_2$ do not differ much from the ideal gaseous state $dr/dT = (c_p)_1 - (c_p)_2$. At 40° the $v_1$ differs only by 0·3 %, at 50° by 0·6 % from the ideal condition, and the calculations then yield for $dr/dT$ at those temperatures the values − 0·535 and − 0·534 cal./degree. The differences between the heats of evaporation of water at 0° and at 30°, 40°, 50° give the values 596·1, 596·2, 596·1 cals. for the heat of evaporation of water $r_0$ at 0°, when the caloric unit is taken at 15°; for mean calories Dieterici found 594·8.

**H. v. Steinwehr** (*ibid.*, p. 200).—Steinwehr replies that he did not claim to have demonstrated the validity of his formula for more than the range 30° to 180°, though extrapolation down to 0° might be admissible. **H. B.**

**275.** *Gas Ignition at Reduced Pressures by Transient Arcs.* **W. M. Thornton.** (Phil. Mag. 40. pp. 450–460, Oct., 1920.)—The transient arc formed at the point of break of a current-carrying circuit is an active source of ignition. This arc consists of a stream of charged particles passing from the negative to the positive pole and differs from the disruptive discharge. The ignition of gases especially by non-inductive transient arcs between platinum poles is much more uniform in character than the impulsive-spark ignition [see Abs. 99 (1921)], but the limiting conditions of ignition show, as was to be expected, critical points or phases characteristic of heat and of ionisation. The break is made electromagnetically between platinum rods by drawing the iron rod, to which they were attached, into the core of a coil. The curves obtained by plotting the current intensity (up to 2 amps. with direct current) as ordinate against the gas pressure (from 0·2 to 1·4 atmo.) in hydrogen, methane, ethane, propane, are all of the inverted N type, the amperes falling to a minimum as the pressure is raised, rising once more, and falling off again, then more gradually; the oscillation is strongest for hydrogen, and stronger for propane than for the other hydrocarbons. With alternating current (frequency 36 at 200 volts) the oscillation is only visible in hydrogen and faintly in methane; in the other cases there is no rise, but a descent in steps; the influence of change of frequency is very strong. The ignition of the gases by hot wires [Abs. 236 (1920)] is referred to. The d.c. curve in hydrogen resembles the curve of change of spark of Clausius; a formula expressing the essential parts of break-spark ignition is deduced. The d.c. and a.c. curves for break-spark ignition of coal-gas show steps; in coal-gas the d.c. oscillation is strong, the a.c. oscillation less marked, but the a.c. ignition is much easier. H. B.

**276.** *Process for Testing the Content of Combustible Materials in Air.* **E. Beckmann.** (Preuss Akad. Wiss. Berlin, Ber. 34. pp. 924–936, 1914.) —The results of an investigation into the subject of fire-damp occupy this paper. The origin of fire-damp and its evaluation is dealt with in Part I. The various kinds of coal are first discussed, and the mode of occurrence of methane therein. The danger limits are criticised, and a content of only 3 % of methane in air laden with coal-dust is stated to be sufficient for an explosion. Previously up to 6 % methane had been regarded as danger-free. Davy's lamp next receives attention, since by its aid ½ % of fire-damp may be recognised, and this is followed by a description of various other forms of testing apparatus. The author himself first attempted a solution of the problem by chemical means, seeking for a suitable oxidation of methane into carbon dioxide and water capable of adaptation to analytical purposes. These experiments, however, met with no success, and the standpoint was adopted of testing the danger of a methane-air mixture by its explosibility. An apparatus for preliminary testing is first described, and is followed by a detailed account of that for the main experiment. A single test occupies about 3 minutes by this method. Experiments are then described for combustions made with excess of oxygen in the first instance, and a deficiency in the second. In the latter case carbon monoxide makes its appearance. Section II embodies an investigation into mixtures of air with ordinary coal-gas or hydrogen. Diagrams of the apparatus are included together with tables of results. H. H. Ho.

**277.** *Radiation and Convection from Heated Surfaces.* **T. Barratt and A. J. Scott.** (Phys. Soc., Proc. 32. pp. 361–371; Disc., 372–373, Aug., 1920. From the National Physical Laboratory.)—The relative and absolute amounts of radiation and convection from surfaces heated to about 100° C. in air were measured as follows: Steam was passed through the cylinders or spheres, the surface temperature being measured by a thermo-junction. The total amount of heat lost from the surface was determined from the equivalent mass of steam condensed. This was done with the surface (*a*) "bright," (*b*) "dead-black." The relative amounts of radiation alone from these two surfaces were then found with the aid of a thermopile. If $h_1$ is the total heat lost, and $r_1$ the radiation, per cm. per sec. per 1 deg. C. excess of temperature for the "black" surface; $h_2$ and $r_2$ corresponding quantities for the "bright" surface; and $c$ the convection in each case, then if $h_1 = ah_2$, $r = br_2$,

$$\frac{r_2}{h_2} = \frac{a-1}{b-1} \quad \text{and} \quad \frac{r_1}{h_1} = \frac{b(a-1)}{a(b-1)}$$

The numerical values of the radiation, convection, and total heat are then easily calculable, and are given in tables. It is found that the amount of *convection* per cm. is inversely proportional to the square root of the diameter of a cylinder, and to the cube root of the diameter of a sphere. AUTHORS.

**278.** *Radiation from a Perfectly Diffusing Circular Disc.* II. **J. W. T. Walsh.** (Phys. Soc., Proc. 32. pp. 315–325, Aug. 15, 1920.)—

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In a previous paper [Abs. 849 (1920)] an expression was obtained for the amount of flux received from a perfectly diffusing circular disc (*i.e.*, one radiating according to the cosine law) by another parallel and coaxial disc of given diameter, placed at a given distance from it. The method was also extended to determine the amount of flux received by the sides of an infinitely long coaxial circular cylinder bounded by a disc parallel to the radiating disc.

In the present paper the results already obtained are applied to give (1) the amount of flux reflected to any point of the radiating disc if the non-radiating disc reflect the flux incident upon it according to the cosine law, and (2) the flux received at any point in the penumbra of the shadow formed when a radiating disc is partially eclipsed by a second coaxial opaque disc.

A treatment is also given of the problem of finding the flux incident upon a disc inclined at an angle with the radiating disc. So far, the accurate solution of this problem has only been obtained when the edges of both discs form small circles of the same sphere (*loc. cit.*). A solution in the form of an infinite series will be obtained for the less specialised case when the axis of the receiving disc passes through the centre of the radiating disc, the two discs being unrestricted as to relative size.

AUTHOR.

**279.** *Constants of Radiation of a Uniformly Heated Enclosure.* **W. W. Coblentz.** (Bureau of Standards, Bull. 15. pp. 529–535 [Sci. Papers No. 357], 1920.)—The object of this paper is to give experimental data on atmospheric absorption as it affects the measurements of the radiation constants. The paper gives also a recalculation of the coefficient of total radiation of a uniformly heated enclosure, taking into consideration all losses by reflection from the receivers, as well as losses by atmospheric absorption. The value of the coefficient obtained is $\sigma = (5\cdot722 \pm 0\cdot012) \times 10^{-12}$ watt cm.$^{-2}$ deg.$^{-4}$, which is the same as previously obtained [Abs. 699 (1916)]. The effect of atmospheric absorption upon data obtained at Naples is discussed, and it is concluded that, if a correction is made for absorption by water-vapour, the value of $\sigma$ obtained at that station is of the order of 5·7. This is about the average value of all observers when corrections are made for atmospheric absorption.

The present status of the constant of spectral radiation is discussed, and the conclusion is reached that, in view of the uncertainty of the temperature scale, and of the different experimental methods used, the mean of the values of this constant, which have been used by the Reichsanstalt and by the Bureau of Standards, namely, $C_2 = 14{,}325$, is probably close to the true value. A. W.

**280.** *Stationary Heat Distribution on Radiating Spherical Surface.* **K. Aichi.** (Phys. Math. Soc. Japan, Proc. 2. pp. 196–208, Oct., 1920.)—A continuation of previous work [see Abs. 404 and 732 (1920)] for the case of a radiating spherical surface in temperature equilibrium, the heat sources being (*a*) situated at a point, (*b*) distributed along a curve, (*c*) a doublet. The solution of the problem when the temperature distribution is known is also given. J. W. T. W.

**281.** *A Modified Formulation of the Quantum Hypothesis in which both Emission and Absorption of Radiation are Continuous.* **M. Planck.**

(Preuss. Akad. Wiss. Berlin, Ber. 34. pp. 918–923, 1914.)—In the author's first formulation of the quantum hypothesis the assumption was made that the energy of an oscillator which absorbs and emits thermal radiation of oscillation-frequency $\nu$ is always a whole multiple of $h\nu$. This assumption has raised insuperable difficulties, such as that an oscillator of higher frequency can accept suddenly from its surrounding radiation field of smaller intensity a whole energy-quantum $h\nu$. The author then investigated a modification of the hypothesis in which only the emission of the thermal radiation was assumed to be discontinuous, while the absorption was regarded as continuous. He showed that with suitable assumptions a stationary energy distribution was afforded which led to the radiation formula verified by experiment. This assumption, however, of quanta-like emission of thermal radiation leads to further difficulties which in the present paper are limited to the case of uniform rotation of an electric dipole of constant moment. Here, where the surrounding electromagnetic field is stationary throughout, it is scarcely possible to understand how quanta emission can take place. The present paper, therefore, attempts a further advance by investigating the case for continuous absorption and emission of thermal radiation. This assumption implies that the quantum action is not between the oscillators and the wave radiation, but takes place solely between the oscillators and the free particles (molecules, ions, electrons), which exchange energy by impacts with the oscillators. The laws of classical electrodynamics then hold good for every interchange between the oscillators and the free radiation. The author confines himself solely to the energy exchange between a large number, N, of homogeneous static rectilinear oscillators of definite frequency $\nu$ and a large number $N^1$ of freely moving particles. Any action between the oscillators and the free-wave radiation is not taken into account. Section II of the paper deals with the physical assumptions made. Section III considers changes of state, and Section IV the stationary distribution of energy. If oscillators of different frequencies are present, the considerations advanced are not essentially modified, since the free particles play the same *rôle* towards all the oscillators. The author believes this method of investigation to admit of positive results. H. H. Ho.

**282.** *On the Heat of Admixture; Proof of Dolezalek's Principle.* **H. Cassel.** (Zeits. f. Physik, 2. 2. pp. 146–147, 1920.)—Dolezalek's principle states that every thermal effect on admixture of condensed substances or every curvature of the vapour-density isotherm indicates chemical action. This was derived from the experimental fact that a mixture results whose vapour-pressure isotherm is rectilinear. The author of the present paper has previously shown, somewhat briefly, that the above principle may be deduced from Planck's conception of the Nernst theorem. He now gives a more complete proof of this general principle. The paper is mathematical throughout. H. H. Ho.

**283.** *Measurement of Planck's Constant "h" by Limits of Continuous X-Ray Spectrum.* **M. de Broglie.** (J. de Physique et le Radium, 1. pp. 39–43, Aug., 1920.)—A *résumé* of the more important investigations in which this method is employed. Special reference is made to the work of Millikan, Rutherford, Bohr, Hull, Ledoux-Lebard et Dauvillier, Blake and Duane, Wagner, Birge, and the author. A. B. W.

**284.** *On the Critical Quantities of Mercury in Connection with the Increase of the Molecular Attraction on Dissociation of the Double Molecules.* I (Experimental). II (Theoretical). **J. J. van Laar.** (K. Akad. Amsterdam, Proc. 23. 2 and 3. pp. 267–281, and pp. 282–298, 1920.)—Previous work on the critical quantities of mercury is first referred to [see Abs. 75 (1918)], where the conclusion was drawn that the substance is quite or almost quite bi-molecular at $T_c = 1260°$ abs. (= 987° C.); $p_c = 192$ atmos. It appears, however, that the critical temperature of mercury lies much higher than 900° or 1000° C. Traube and Teichner found no critical phenomena at 1000° C., Happel calculated $T_c = 1097°$ C., $p_c = 456$ atmos., Menzies arrived at 1275° C., while from Königsberger's experiments the value was indicated as above 1400° C. Miss Bender's experiments showed that at 1500° C. there was still liquid mercury present. The author now discusses whether the high critical temperature of 1700° abs. can be theoretically justified. If such a high critical temperature and pressure is to be reached the double molecules must be dissociated at $T_c$ to a slight amount, and it is shown that even with a very small dissociation a fairly large factor appears, which increases the value of $T_c$ by about 30 % and that of $p_c$ to more than four times the amount of the original value. These extraordinary circumstances connected with the critical temperature and pressure of mercury have induced the author to extend his former theory concerning the critical quantities on association for the important case that "a" is considerably increased in consequence of the dissociation of the double molecules. According to the author's recent investigations, this case is met with everywhere where the dissociation (as for Hg) leads to free atoms, for which the increased attractions of valency are so enormously much greater than for the compounds. The paper commences with a consideration of vapour pressures and values of the vapour densities $D_2$ (the density of the saturated vapour), followed by the values of $D_1$ (those of the liquid densities) and $D_1 + D_2$. The values of $D_1 + D_2$ near $T_c$ and those of V at different temperatures are then examined. General formulæ for $v_c$, $T_c$, $p_c$, and S are next derived, and a calculation of $\theta$ and $\pi$ is made from them. $RT_c = \frac{8}{27} n \frac{a_c}{b_c} \times \theta$ and $p_c = \frac{1}{27} \frac{a_c}{b_c^2} \times \pi$, where $n$ represents the factor of association. This discussion of the experimental data occupies Part I of the paper. The theoretical examination forms the subject matter of Part II, which commences with the derivation of a general relation for the degree of dissociation $x$ of the double molecules. This is followed by a determination of $(dx/dv)_t$, the differential quotient $(dp/dv)_t$, and the value of $RT_c$. Next comes the evaluation of the second differential quotient $(d^2p/dv^2)_t$ and of $r = v_c/b_c$, and finally the calculation of some numerical values. Part II is mathematical throughout. H. H. Ho.

## SOUND.

**285.** *Vibrations of an Elastic Plate touching Water.* **H. Lamb.** (Roy. Soc., Proc. 98. pp. 205–216, Nov. 3, 1920.)—In connection with the problem of submarine signalling the question arose as to the pitch of the fundamental note of a thin circular plate or diaphragm of given material and dimensions, filling an aperture in a plane wall which is in contact on one side with an otherwise unlimited mass of water. The present paper, which includes some extensions, is now published by permission. To simplify the theoretical treatment, the wall is supposed to be rigid, and the plate to be firmly clamped to it along the circumference, although those conditions are only imperfectly fulfilled in practice. Even with these limitations an exact solution is out of the question, but a sufficient approximation can be obtained by Rayleigh's method of an assumed type ["Theory of Sound," § 90]. It is known that the frequency estimated in this way will be somewhat too high. Thus the author finds (in the absence of water)

$$p/2\pi = 0{\cdot}4745\ hc_1/a^2, \text{ against } p/2\pi = 0{\cdot}4693\ hc_1/a^2$$

as found by F. Meyer zur Capellen, in which $h$ is thickness of the plate of radius $a$, and $c_1$ the speed of extensional waves in an infinite thin plate of the same material and thickness. For an iron plate 7 in. diameter and ¼ inch thick $p/2\pi = 1013$, by the above formula.

The presence of the water, in this problem, has the effect first of lowering the frequency on account of the increased inertia, and secondly of damping the vibrations owing to the energy carried off in the form of sound-waves. When this first effect is calculated, it is found that, in the plate just referred to, the frequency is lowered in the ratio 0·542, and is accordingly reduced to about 550, *i.e.*, for the gravest mode of vibration. For the second effect, it is found that if the amplitude diminishes as $e^{-\alpha t}$, then for the numerical case in question, $p/2\pi\alpha = 5{\cdot}16$. In spite of the small persistence thus indicated, the vibrations are far from being "dead beat." The damping though considerable, is not sufficient to affect the frequency appreciably, this influence being always of the order $\alpha^2/p^2$, which is less than one-thousandth in the present case. There is also a considerable degree of selective resonance to external sources of sound. The general rule is that the energy of resonance falls to one-half the maximum when the frequency of the source differs from the natural frequency of the resonator by the fraction $\alpha/p$, approximately. Thus, in the above example, where the frequency (as modified by water) is about 550, the range over which the energy will exceed half the maximum is confined between the limits 530 and 570 nearly. E. H. B.

**286.** *Absorption of Sound by Rigid Walls.* **P. E. Sabine.** (Phys. Rev. 16. pp. 514–518, Dec., 1920.)—*Absorption assumed to be due to porosity,* the absorbing walls being so massive that flexural yielding is presumably negligible. Upon this assumption, *Rayleigh's theory* indicates that the absorption by such a wall is very nearly proportional to the square root of the frequency of the sound.

*Absorption is approximately a linear function of the square root of the frequency*, as shown by experiments for a range of frequencies between 64 and 4096 periods per sec., but the absorption frequency curve does not pass through the origin, and at higher frequencies the absorption is greater than can be accounted for by porosity alone.

*Selective transmission* of a frequency whose wave-length in the wall is twice the thickness gives a possible explanation. Absorption experiments at still higher frequencies are desirable. AUTHOR.

**287.** *Oscillographic Investigation of Microphones for Hydrophones.* **P. Ludewig.** (Phys. Zeits. 21. pp. 305–311, June 15, 1920.)—Describes several series of tests made to investigate the natural frequencies and sensitiveness of several microphones of particular types available (the VKU and Simons microphones) and of a modified type devised by the author (torsion microphone). In the VKU type the principal natural frequency was determined by the vibrations of the supporting pillar. The results are not of general application to microphones other than those referred to. W. H. G.

## ELECTRICITY AND MAGNETISM.

### THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

**288.** *Internal Energy of the Lorentz Electron.* **S. R. Milner.** (Phil. Mag. 40. pp. 494–499, Oct., 1920.)—In order to make the Lorentz electron amenable to the laws of mechanics it is necessary to ascribe to it a certain amount of energy in addition to that which is accounted for by the electric and magnetic forces of the field. This energy, apparently non-electromagnetic in character, is assumed to be located in what may be called the "nucleus" of the electron (to distinguish it from the surrounding electronic field). The postulation of this internal energy is essential for two separate reasons. In the first place, considering the electron as a system capable of being set in motion by a mechanical force, we must have simultaneously satisfied the two conditions: (1) that the force is measured by the rate of increase of momentum of the system, and (2) that its activity is measured by the rate of increase of the total energy. But this fundamental law of mechanics is not satisfied unless to the energy of the electronic field the internal energy is added [Lorentz, "Theory of Electrons"]. In the second place, the internal energy is required to make the electron fit into a relativistic scheme, namely, to make its total energy at any speed equal to $c^2$ times its mass. The object of the present note is to point out that there is another reason for postulating the existence of this internal energy, and it is one which has a more clearly defined electromagnetic character than either of the above. It comes from a consideration of the Poynting flux of energy in the field of a uniformly moving electron. If we make the supposition that Poynting's expression forms a valid measure of the energy flux in every part of an electromagnetic field, it is possible to deduce a value of the internal energy which is in complete accord with that necessitated by the mechanical theory. A. W.

**289.** *Electromagnetic Field in an Inhomogeneous and Isotropic Medium.* **F. Massardi.** (N. Cimento, 20. pp. 95–118, Sept.–Oct., 1920.)—The treatment is entirely mathematical and cannot be dealt with suitably in an abstract. L. H. W.

### DISCHARGE AND OSCILLATIONS.

**290.** *Collisions of Electrons with Molecules of a Gas; Distribution of Velocity of Electrons moving under an Electric Force.* **J. S. Townsend.** (Phil. Mag. 40. pp. 505–511, Oct., 1920.)—In the first part of this paper the author criticises Pedersen's method of calculating ionisation potentials from the currents obtained through a gas between parallel plates at various distances apart, when electrons are set free from the negative electrode [Abs. 1189 (1920)]. The formula obtained by Pedersen for the total number $n_a$ of electrons arriving at the positive electrode when $n_0$ electrons start from the negative electrode, is $n_a = n_0\epsilon^{\gamma\alpha(a - l_0)}$,

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the additional ions being generated by collisions in which the velocity of the electrons exceeds a certain critical value. It is pointed out that the only quantity which can be determined directly from such experiments is the product $\gamma a$. Other experiments show, however, that no reliable estimate of the velocity of an electron required to ionise a molecule can be obtained from the value of $\gamma a$ by a calculation founded on the supposition that a large proportion of the kinetic energy of an electron is lost at each collision. This has previously been pointed out. [Abs. 513 (1909)].

The latter part of the paper gives the results of a series of experiments which show how the velocities of electrons are distributed when moving under an electric force in a gas, and which afford a more reliable means of estimating the velocities required to generate ions by collisions. A. W.

**291.** *Carriers of, and Value of e/m for the Anode Rays; Experiments with Lithium and Potassium Halides.* **G. P. Thomson.** (Cambridge Phil. Soc., Proc. 20. pp. 210–211, Sept., 1920.)—Anode rays are formed when a mixture of various metallic chlorides and iodides with graphite is used as the anode in a discharge tube under reduced pressure. They are visible as a slightly diverging pencil of light starting from the anode and very roughly normal to it. In order to investigate the value of *e/m* for the particles which cause this light an insulated Al plate, pierced with a hole in which was fastened the end of a fine tube of 0·33 mm. bore, was placed in the path of the beam, and 2 or 3 cm. from the anode. The parallel beam of rays thus produced was analysed by coincident electrostatic and magnetic fields in the usual manner for positive rays, and the deflected particles allowed to strike on a photographic plate. With exposures of about 20 minutes well-marked results were obtained, the particles affecting the photographic plate in the same manner as positive rays. Using a paste composed of a mixture of KI, LiCl, and graphite, short parabolic arcs appeared whose magnetic displacements were in the ratio $\sqrt{7}$ to $\sqrt{39}$, indicating that they were due to Li and K respectively. On one plate a faint line appeared, corresponding to about 140 atomic weight, which is probably due to iodine, the accuracy being poor for large atomic weights. An absolute determination of *e/m* was made from measurements of the electric and magnetic forces. The result for the more deflected lines corresponded to an atomic weight of 6·9, assuming a single charge, thus confirming the assumption that they are due to singly-charged atoms of lithium. Further experiments are in progress with the object of improving the definition and detecting small proportions of isotopes, if these exist. A. W.

**292.** *Spectro-Photoelectrical Conduction in Solids.* **W. W. Coblentz.** (Optical Soc. of America, J. 4. pp. 249–254, Sept., 1920.)—Numerous solid substances, which have a low electrical conductivity in the dark, have a high electrical conductivity when exposed to light. A study of some of these substances shows that their photoelectrical reactions have the following characteristics: (1) The photoelectrical response, to an equal energy stimulus, is fairly uniform throughout the visible spectrum, terminating in a band or bands of high photoelectrical sensitivity in the extreme red or near infra-red spectrum. (2) The time required to attain equilibrium of the photoelectrical reaction is selective to wave-length. For visible radiation the photoelectrical response is complete in a few seconds; whereas it requires an exposure of one to several minutes to infra-red rays in order to induce the max. photoelectrical response. (3) The effect of increasing the intensity of the radiation stimulus is to produce a greater increase in the photoelectrical response to the long wave-lengths than to the short wave-lengths, with a resultant shift of the maximum of the spectral photoelectric sensitivity curve towards the long wave-lengths. (4) Decreasing the temperature of the substance greatly increases the intrinsic photoelectrical sensitivity throughout the whole spectrum and shifts the max. sensitivity towards the short wave-lengths. [See Abs. 669 (1917).] A. W.

**293.** *Photoelectrical Properties of Molybdenite and Other Substances; Selective Temperature and Voltage Effects.* **W. W. Coblentz.** (Bureau of Standards, Bull. 16. pp. 595–639 [Sci. Papers, No. 398], 1920.)—A description is given of a series of new observations on positive and negative spectrophotoelectric reactions in molybdenite, silver sulphide, and stibnite. With these new data are assembled and correlated the few previously observed photonegative reactions in selenium and stibnite. In view of the numerous variables involved, an attempt was made to determine the effect of each one upon the photoelectrical reaction, while other conditions were kept constant. It was found that the photopositive action resulting from exposure of these substances to radiation is similar to an increase in their electrical conductivity. The photonegative reaction simulates a counter e.m.f. These two opposing effects occur simultaneously. The photopositive reaction occurs quickly and prevails on low voltages. The *photonegative action* usually builds up more slowly and predominates on high voltage. It is *selective* to the wave-length of the radiation stimulus, as well as to the magnitude and direction of the electric current through the crystal. Temperature also affects the phenomenon, and under certain conditions, on exposure of molybdenite, the photonegative reaction occurs first, followed by the photopositive action.

*Molybdenite.*—It was found that, for the short wave-length region of the spectrum extending to about $0{\cdot}67\ \mu$, the photoelectric reaction, in the sample of molybdenite employed, passes from purely positive on low voltages through intermediate stages to an apparently pure negative reaction on high voltages. Furthermore, this reaction is dependent upon the direction of the current through the crystal. On high voltages a secondary negative reaction appears to be present. The recovery after exposure is also unusual. When operated on the intermediate voltages, on shutting off the radiation stimulus, the negative effect increases still further, after which the crystal gradually returns to its former dark conductivity. However, at moderately low temperatures, $-20°$ C., the recovery from the negative reaction is irregular, resulting in overshooting, so that momentarily the apparent resistance is lower than the normal dark resistance. At a given temperature the region of transition in the spectrum, in which the action changes from negative to positive, is very narrow (less than 9 Å.). It appears to shift slightly toward the short wave-lengths with decrease in temperature or increase in intensity of the radiation. The critical voltage is very small. Under certain temperature conditions an increase of 1 volt sufficed to change a small positive-negative galvanometer deflection of ± 1 cm. into a pure negative deflection of perhaps

— 25 cm. With decrease in temperature the potential must be increased in order to produce a negative reaction.

For radiations of wave-lengths greater than about 0·7 μ the photoelectric reaction of the sample of molybdenite was positive, whatever the magnitude or direction of the current through the crystal. Similar results were obtained on photopositive samples of molybdenite and of stibnite.

*Acanthite (silver sulphide).*—The photoelectric reaction in this mineral differs from that of the negatively reacting sample of molybdenite in that, at room temperature, the partial *photonegative reaction* is *non-selective* to wave-length. Moreover, for the operable voltages that could be applied, no purely negative response could be produced, the reactions being similar to those observed in molybdenite at intermediate voltages. At low temperatures the positive-negative reaction disappeared and, on exposure to radiation, there was a momentary negative reaction followed by a very large positive galvanometer deflection.

*Stibnite.*—The data available make it appear that the behaviour of stibnite is similar to that observed in molybdenite.

*Selenium.*—The negative reaction of selenium to etherochromatic radiation, observed by Ries and by Brown [Abs. 1563 (1911)], is similar to that observed in molybdenite on the intermediate voltages.

The paper also gives data on unipolar conduction, and in three appendices are given (1) further data on the previously observed frequency relation in the bands of spectrophotoelectric sensitivity of molybdenite, (2) a survey of the general spectrophotoelectric properties of substances, and (3) a description of experiments on thermal radiophonic signalling. A. W.

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**294.** *Effects of Electron Collisions with Atmospheric Neon.* **F. Horton** and **[Miss] A. C. Davies.** (Roy. Soc., Proc. 98. pp. 124–146, Oct. 1, 1920.)—This paper is substantially the same as that dealt with in Abs. 127 (1921). A. W.

**295.** *Ionisation and Resonance Potentials of the Non-Metals.* **F. L. Mohler** and **P. D. Foote.** (Bureau of Standards, Bull. 16. pp. 669–700 [Sci. Papers, No. 400], 1920.)—The methods previously applied to the study of critical potentials in the metallic vapours have been, with some modifications, used for the elements P, I, S, N, O, and H. The results obtained are described at length and tabulated. Excepting the case of hydrogen, these elements all show a resonance and ionisation potential similar in relative magnitude to those observed in metallic vapours [see Abs. 297 (1921)]. Except for I and S, the actual magnitudes of the potentials are larger than the potentials observed in any of the metals. In the case of S there is evidence that there are two resonance potentials and but one ionisation potential.

*Difference between Electron Currents in Non-Metals and those in Metallic Vapours.*—The most marked difference between electron currents in these elements in comparison with metallic vapours is a lack of sharpness in the critical potentials, which becomes more marked as the pressure is increased. It is undoubtedly due to the fact that electron collisions are slightly inelastic at all potentials. The effect was greatest in iodine and decreasingly less in S, O, P, N, and H. The order given is doubtful, but is seen to agree roughly with the order of electronegative properties of the elements. Hydrogen with its two resonance potentials and ionisation potentials is apparently unique. The curves are best explained as due to a mixture, at least near the kathode, of $H_2$ and $H_1$ in proportions varying with experimental conditions. Nitrogen is certainly much less dissociated than hydrogen under similar conditions, so it would seem that the single resonance and ionisation potentials observed for it must be ascribed to $N_2$ molecules. This gives rise to difficulties, since the resonance potential corresponds to a frequency of the line emission spectrum and not of the band spectra. The following table gives a summary of the critical potentials of the six elements studied, together with the related spectral lines and limiting wave-lengths. The wave-lengths in brackets are computed from observed potentials.

| Element. | Resonance. | | | Ionisation. | | |
|---|---|---|---|---|---|---|
| | Observed. | Theoretical. | Wave-length λ, in A. | Observed. | Theoretical. | Wave-length λ, in Å. |
| Phosphorus | 5·80 | — | (2130) | 13·3 | — | (928) |
| Iodine ...... | 2·34 | — | (5300) | 10·1 | — | (1220) |
| Sulphur .... | 4·78 | — | (2580) | 12·2 | — | (1010) |
| Nitrogen .... | 8·18 | 8·270 | 1492·8<br>1494·8 | 16·9 | — | (730) |
| Oxygen ..... | 7·91 | — | (1560) | 15·5 | — | (796) |
| Hydrogen .. | 10·40 | 10·16 | 1215·6 | 13·3 | 13·54 | 911·78 |
| | 12·22 | — | — | 16·5 | 16·26 | — |

[See Abs. 297 and 434 (1919).] A. W.

**296.** *Ionisation Velocity for Electrons in Helium; Effect of Presence of Impurity.* **F. Horton** and **[Miss] D. Bailey.** (Phil. Mag. 40. pp. 440–450, Oct., 1920.)—A number of experiments have been carried out on the effect of a trace of impurity on the measurement of the ionisation potential for helium. The experiments show that the ionisation which has been detected in He when electron velocities of less than 25 volts were used, is due to the indirect ionisation of traces of impurities by the helium radiation. It is consequently of the greatest importance to maintain helium perfectly pure when attempting to investigate the ionisation of the gas by electron collisions. The only satisfactory method when a glass apparatus is used is to have a slow circulation of freshly purified helium through the ionisation chamber during the experiments. It is possible that if fused silica were substituted for glass, contamination of the gas would be less likely to occur.

The curves given indicate that the minimum ionisation velocity for electrons in helium is 25·0 volts, a slightly lower value than that obtained by Horton and (Miss) Davies [Abs. 781 (1919)]. A. W.

**297.** *Resonance Potentials and Low Voltage Arcs for Metals of the Second Group of the Periodic Table (Hg, Ca, Ba, Sr, Mg, Zn, Cd).* **F. L. Mohler, P. D. Foote,** and **W. F. Meggers.** (Optical Soc. of America, J. 4. pp. 364–370, Sept., 1920.)—Previous papers [Abs. 297 (1919) and

1284 (1920)] have discussed the resonance and ionisation potential measurements for five metals of the second group of the periodic table. The results showed in every case a resonance potential corresponding, by the quantum relation $Ve = h\nu$, to the combination series line $1 \cdot 5S - 2p_2$ (Paschen notation) and an ionisation potential corresponding to the limiting frequency of this series 1·5S. Calcium showed in addition a second resonance potential corresponding to the frequency 1·5S — 2P, the first line of the principal series of single lines converging at the same frequency 1·5S. Spectroscopic studies of low-voltage arcs in these metals are not entirely in accord with the work on current–potential measurements. The search for a second resonance potential required a more sensitive means of detecting inelastic impact than is possible with the type of three-electrode vacuum tube previously used. In the present work a four-electrode tube was used in which a hot-wire kathode is surrounded by two cylindrical grids and a cylindrical anode. The grids, of which one is close to the kathode and the other close to the anode, are maintained at the same potential by metallic contact. A variable accelerating field for electrons is used between the kathode and inner grid, and the current reaching the anode against a small retarding field between the outer grid and anode is measured. Typical curves are given for Hg, Ca, Mg, Zn, and Cd. A number of curves were obtained for each element, and the mean values are given in the following table, with the values to be expected in barium and strontium :—

IONISATION AND RESONANCE POTENTIALS.

| Metal. | Paschen Series Notation. | Wave-length Å. *in vacuo.* | Computed Potential. | Observed Potential. |
|---|---|---|---|---|
| Zinc .. .. | 1·5S | 1319·98 | 9·3524 | 9·3 |
| | $1 \cdot 5S - 2p_2$ | 3076·88 | 4·0122 | 4·18 |
| | 1·5S — 2P | 2139·33 | 5·7705 | 5·65 |
| Cadmium .. .. | 1·5S | 1378·69 | 8·9542 | 9·0 |
| | $1 \cdot 5S - 2p_2$ | 3262·09 | 3·7844 | 3·95 |
| | 1·5S — 2P | 2288·79 | 5·3937 | 5·35 |
| Mercury .. .. | 1·5S | 1187·96 | 10·3918 | 10·2 |
| | $1 \cdot 5S - 2p_2$ | 2537·48 | 4·8651 | 4·76 |
| | 1·5S — 2P | 1849·60 | 6·6744 | 6·45 |
| Magnesium .. | 1·5S | 1621·72 | 7·6123 | 8·0 |
| | $1 \cdot 5S - 2p_2$ | 4572·65 | 2·6997 | 2·65 |
| | 1·5S — 2P | 2853·06 | 4·3269 | 4·42 |
| Calcium .. .. | 1·5S | 2028·20 | 6·0867 | 6·01 |
| | $1 \cdot 5S - 2p_2$ | 6574·59 | 1·8777 | 1·90 |
| | 1·5S — 2P | 4227·91 | 2·9198 | 2·85 |
| Strontium .. | 1·5S | 2176·94 | 5·6708 | |
| | $1 \cdot 5S - 2p_2$ | 6894·45 | 1·7906 | |
| | 1·5S — 2P | 4608·61 | 2·6787 | |
| Barium .. .. | 1·5S | 2379·28 | 5·1885 | |
| | $1 \cdot 5S - 2p_2$ | 7913·52 | 1·5600 | |
| | 1·5S — 2P | 5537·04 | 2·2295 | |

*Low-voltage Arcs.*—The similar characteristics of electronic impact in vapours of the metals of the second group require that their spectra in low-voltage arcs should be analogous. Hence the single-line spectrum of each of these metals should be $1\cdot 5S - 2p_2$. McLennan observed $1\cdot 5S - 2P$ for the single-line spectrum of magnesium, and could not detect the presence of $1\cdot 5S - 2p_2$ below the ionisation potential. The evidence that ionisation is unnecessary to produce the line $1\cdot 5S - 2P$ ($\lambda = 2852$) is conclusive, so that the experiments were concerned with determining whether or not the line $1\cdot 5S - 2p_2$($\lambda = 4571$) is excited below the ionisation potential. A cylindrical anode and a hot-wire kathode along its axis were placed at one end of a long tube with a glass window sealed on the other end. Only the part of the tube near the electrodes was heated. The light of the incandescent kathodes was shielded from the window so that the glow discharge appeared against a dark background. A photograph reproduced shows conclusively the existence of $1\cdot 5S - 2p_2$($\lambda = 4571$) as the single-line spectrum of magnesium. At 14 volts the transition to the single-line spectrum is most marked.

The results obtained enable a statement to be made of the general laws for the phenomena of electron impacts with molecules of the metals of the second group, for which there are at least three types of inelastic impact, two resonance potentials, and an ionisation potential. A. W.

**298.** *Relative Ionisation Potentials of Gases as Observed in Thermionic Valves.* **G. Stead and B. S. Gossling.** (Phil. Mag. 40. pp. 413–425, Oct., 1920.)—*Method.*—In the experiments described the procedure was similar to that employed by Bazzoni [Abs. 326 (1917)], and consisted in observing the effects of the presence of gas on the form of curves representing the variation of the current leaving an incandescent kathode with change in the potential applied to the collecting electrodes. The valves used were of the well-known form with cylindrical anode, helical grid, and straight central filament, and the grid and anode were connected together.

*Results.*—Six different gases were used, and the ionisation potentials determined were as follows: mercury vapour, 10·8 volts; argon, 12·5 volts; hydrogen, 15 volts; CO, 15 volts; nitrogen, 17·2 volts; helium, 20·8 volts. These numbers represent the p.d. between the anode and the *negative* end of the filament, so that various corrections are necessary to obtain the proper values. It seems probable that a correction of the order of 0·5 volt may be necessary. The results are compared with those of various other experimenters. Horton and [Miss] Davies have concluded that ionisation does not occur in argon until about 15 volts, and Rentschler gives the value 17 volts. It is very difficult to reconcile this with the behaviour of argon in valves, in which it is hardly possible to avoid the conclusion that strong ionisation occurs at about 12·5 volts. A. W.

**299.** *Centres of Luminescence and Variations of Gas Pressure in Discharge Tubes.* **L. Hamburger.** (K. Akad. Amsterdam, Proc. 23. 2 and 3. pp. 379–394, 1920.)—The results of some observations have previously been given [Abs. 793 (1918)] which show that when discharges are sent through a vacuum tube, variations of gas pressure may occur at the electrodes. These variations arise from the difference between the properties of positive and negative ions. This difference gives rise to (*a*) the phenomena connected with electrostriction, and (*b*) mass trans-

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portation by the electric current. The object of the present paper is to examine the connection between these two effects and the observed variations of gas pressure, and in this connection the centres of luminescence are also considered. It is shown that the observed pressure effects are chiefly due to the difference in the number of molecules that arise on the discharge of positive and negative ions at the anode and kathode. Directly, electrostriction plays only a very subordinate part. The amount of the pressure variations varies with the number, mass, charge, and mobility of the positive and negative ions. Hence the effect is directly dependent on the electric variables, the gas pressure, and also the nature of the gas. A physical interpretation of the various factors affecting the pressure variations is advanced, and this is in agreement with the dependence of the variations on different variables. Evidence is given of the existence in the luminous positive column of both positive and negative ions loaded with matter. The current conveyance is chiefly brought about by the latter.

*Centres of Luminescence.*—The above conclusions when considered with respect to electro-luminescence give support to the theories and views of Child, Franck, and Hertz, and to a certain extent the view recently advanced by Thomson [Abs. 1049 (1919)] that electro-luminescence radiation chiefly takes place with recombination of free electrons with ions. The outer electrons of the atom determine its catalytic properties, and optical confirmation is given for the assumption of dislocated states in the theory of catalysis. A. W.

**300.** *Pressure on the Poles of an Electric Arc.* **S. Ratner.** (Phil. Mag. 40. pp. 511–512, Oct., 1920.)—Duffield has tried to show that the motion of ions within an electric arc and the electric wind could not be expected to produce a pressure upon the poles of the arc [Abs. 1643 (1920)]. J. J. Thomson showed the author some time ago that ions moving under an electric force cannot produce a pressure upon the electrode towards which they are moving, the pull on the electrode during the motion of the ions being balanced by the impact of the ions on the electrode. Duffield, however, entirely overlooks the fact that ions moving *from* an electrode (of the same sign) produce a reaction upon it which is not compensated by any other force, and consequently a strong pressure on the poles of an arc is to be expected as a result of the motion of the ions in the arc. When the arc is not in a vacuum the energy of the ions is partly transferred by collision to neutral gas molecules forming the electric wind, and experiment shows that only a small part of the momentum of this stream is imparted to the electrode, the stream expanding over a large volume. In this case the ions will produce a reaction upon the pole of opposite sign also.

The pressure of the electric wind may be detected upon a vane when the current through the gas is as small as $10^{-10}$ amp., and appears proportional to the current. For a current $10^{-5}$ amp., the pressure, at the lowest estimate, is 25 dynes/cm.$^2$. In the arc when several amperes pass through the gas the expected pressure should be sufficiently strong to smash the carbon poles. But the author has noticed that the pressure of the electric wind increases with current only to a certain limit and then tends to diminish. Thus in a discharge tube the wind pressure disappears when the current is increased to 0·5 amp.; from Duffield's work also the electric wind does not arise in the arc. As the wind originates solely in collisions between ions and gas molecules, it should only increase with current density, and there seems no alternative, in order to explain these results, than to suppose that when the current density is large the carriers of electricity do not collide with the gas molecules, which seems incredible. Further investigation of this phenomenon may throw fresh light on the nature of the discharge through gases. T. H.

**301.** *Calculation of the Ionic Flow of Amplifying Values.* **M. Abraham.** (Archiv f. Elektrot. 8. 1. pp. 42–45, 1919.)—The problem of the ionic flow in values of the "French" type is treated as a purely electrostatic problem, and as such is solved mathematically, giving as results: $D = [\log (a/nc)/\{n \log (b/a)\}]$, where $a$ = radius of grid, $b$ = radius of plate, $c$ = radius of single grid wires, $n$ = number of grid wires.

This result is independent of the radius of the kathode filament.

B. J. L.

## ELECTRICAL PROPERTIES AND INSTRUMENTS.

**302.** *Colour Sensitiveness of Photoelectric Cells.* **E. F. Seiler.** (Astrophys. J. 52. pp. 129–153, Oct., 1920.)—*Colour Sensitiveness Curves of Thirty Photoelectric Cells, including all the Alkali Metals and Hydrides of Na, K, Rb, and Cs.*—As great care was used in mounting the apparatus rigidly, in calibrating the thermo-couple and wave-length scale, and in maintaining a constant source of light, the curves were accurately determined, and this enabled the *wave-lengths of maximum sensitiveness* to be determined within about 1 $\mu\mu$. It was found that as the atomic weight of the alkali metal increases, the max. sensitiveness decreases, the resonance peak becomes broader, and $\lambda_{\max.}$ shifts toward the red. The author suggests that these changes may be associated with the increase in atomic volume. For glass cells filled with argon at low pressure, $\lambda_{\max.}$ was 405, 419, 440, 473, and 539 $\mu\mu$ for Li, Na, K, Rb, and Cs respectively, while for the corresponding hydrides NaH, KH, RbH, and CsH, the values were larger: 427, 456, 481, and 540 $\mu\mu$ respectively. With neon instead of argon, in the case of NaH and KH, $\lambda_{\max.}$ was about 20 $\mu\mu$ shorter. And while, in the case of KH, pyrex cells gave the same curve as glass ones, quartz cells showed a longer $\lambda_{\max.}$ for both KH and RbH, contrary to what we should expect from differences in absorption. Since the effects of gas and of cell wall were not eliminated and the normal and selective photoelectric effects were not differentiated, the curves are characteristic of the particular cells rather than of the various metals alone; nevertheless it is of interest to note that the products of $\lambda_{\max.}$ with (1) resonance potential, (2) ionisation potential, and (3) absolute melting temperature of the corresponding metals are each roughly constant. The hydride cells were somewhat more sensitive than the corresponding metal cells.

*Fatigue Tests of Two Photoelectric Cells.*—The effect of illuminating a K cell for 525 hours was to increase its sensitiveness by about 70 per cent., whereas a KH cell remained constant in sensitiveness during 1000 hours' illumination.

*Preparation of a Lithium Photoelectric Cell.*—It was found possible to dissolve lithium in ethylamine if absolutely dry and if a trace of ammonia was present. A uniformly distributed layer of lithium was obtained by evaporating the solution.

*Method of preparing pure ethylamine* is described. Author.

**303.** *Construction of Thermo-Couples by Electro-Deposition.* **W. H. Wilson** and **Miss T. D. Epps.** (Phys. Soc., Proc. 32. pp. 326–339; Disc., 339–340, Aug. 15, 1920.)—Hitherto thermoelectric arrangements have usually been made by one method only—by joining together with solder two metals suitably chosen. The difficulty of making satisfactory soldered joints between the elements of thermopiles is considerable when there are a large number of closely packed junctions, and the authors give details of a method which they have devised in order to avoid these difficulties. It consists in using a continuous wire of one of the elements and coating with an electrolytic deposit of another metal those parts of it which have to form the other element. If this electrolytically deposited metal has a conductivity considerably greater than that of the first metal and a fairly thick sheath is deposited, a thermo-couple is produced which is not appreciably impaired in efficiency by the short-circuiting effect of the core. Constantan wires coated with Cu or Ag sheaths were found to be suitable for most purposes.

In the *discussion*, **R. S. Whipple** commended the device as likely to be of great service to physicists in many cases, *e.g.*, in the measurement of radiation. He mentioned that Hill has recently been measuring the rise of temperature of nerves in action by means of these couples. **W. H. Wilson** stated that he had been able to measure a temperature difference of 1/1000° C. with these junctions. J. J. S.

**304.** *Action of Roentgen and Gamma Radiations upon the Electrical Conductivity of Selenium Crystals.* **A. M. McMahon.** (Phys. Rev. 16. pp. 558–564, Dec., 1920.)—*Action of $\gamma$- and Roentgen Radiations demonstrated.*—The increase in conductivity of selenium cells accompanying the absorption of X-rays has been found characteristic of individual crystals of metallic Se. A similar effect upon the crystals has been observed to be produced by the absorption of the $\gamma$-rays of radium. The fact that a crystal fatigued to $\gamma$-rays is fatigued also to X-rays is evidence that the action in the two cases is similar. The indications are that the crystals are approximately twice as sensitive to $\gamma$-rays as to X-rays of the type used (L rays of tungsten).

*New Electro-mechanical Properties.*—Increase of mechanical pressure upon a crystal results in an increase of its sensibility both to X-rays and $\gamma$-rays. This is exactly the same result, qualitatively, as that secured by Brown in his study of the light effect [Abs. 1879 (1914)].

*Action of Separate X-ray Frequencies.*—Unsatisfactory results obtained in the study of the strong lines of the L radiation of tungsten are thought to be due to the low intensities afforded by the X-ray spectrometer. Another method of attack is being planned.

*Comparison of the Light, X-ray, and $\gamma$-ray Effects upon an Isolated Crystal.*—Calculations made upon the basis of the energy absorbed indicate that a selenium crystal is most sensitive to $\gamma$-rays. The ratios of the change in conductivity to absorbed energy for exposures of one minute are 33·2, 58·5, and 108·9 mhos/joules respectively. Author.

**305.** *Clark Standard Cell; Causes of Failure.* **E. C. McKelvy** and **M. P. Shoemaker.** (Bureau of Standards, Bull. 16. pp. 409–420 [Sci.

Papers No. 390], 1920.)—The ordinary hermetically sealed Clark cell is subject to two types of failure: the cracking of the glass near the amalgam, and the interruption of the circuit by the gradual formation of gas in the amalgam limb. The cracking of the glass has long been known to be due to the alloying of the amalgam with the Pt wire and a resultant increase in the diam. of the wire. The trouble may be largely overcome by employing platinum wire which has previously been subjected for a short time to the action of hot 10 % zinc amalgam, using a lead sealing-in glass. It seems likely that the difficulty can also be remedied by the employment of vessels made entirely of Jena $397^{III}$ glass, or by using this glass as a sealing-in glass. The formation of hydrogen gas in the amalgam limb of the cell seems to be unavoidable, but its presence has no appreciable effect on the e.m.f. of the cell. It seems probable that gas is formed because of a slight acidity of the zinc sulphate solution, or because of the gradual diffusion of acid from the kathode limb, in case the mercurous sulphate used as a depolariser contains free acid or hydrolyses into free acid and a basic sulphate in saturated zinc sulphate solution. The difficulty is reduced to a minimum by using the smallest excess of crystals required to ensure saturation at the highest temperature at which the cell is likely to be used. F. E. S.

**306.** *High-Frequency Resistance and Inductance of Parallel Cylindrical Wires; New Integration Method for Computations.* **H. L. Curtis.** (Bureau of Standards, Bull. 16. pp. 93–124 [Sci. Papers No. 374], 1920.)—The method which has been used hitherto for computing the alternating-current resistance and inductance of wires is to determine the differential equations of the magnetic field and solve these equations, taking into account the conditions imposed by the shape of the conductor. The author has developed a novel integration method. He divides the current into an infinite number of straight filaments. The magnetic field at any point is the sum of the magnetic fields of all the filaments, and the back e.m.f. in a filament is determined by the rate at which the magnetic fields of all the other filaments cut this filament. He first considers the case of the current in a cylindrical wire when the return current is so far away that its effects can be neglected. For a filament he deduces that $E = U_x \rho l + \int\!\!\int M_{xy} \frac{\partial U_y}{\partial t} \partial S$, where E is the applied e.m.f., $U_x$ the current density at $x$, $U_y$ the current density at $y$, $\rho$ the volume resistivity, $l$ the length, and $\partial S$ an element of the cross-section. $M_{xy} = 2l\left\{(\log(2l/d) - 1\right\}$ = the mutual inductance between the filaments at $x$ and $y$, $d$ being the distance between them. If $\phi$ be the angle of lag of the current density at $x$ behind E, U cos $\phi$ and U sin $\phi$ are symmetrical round the centre, and can thus be expanded in power series of $r$. The final results are in exact agreement with the formulæ given by Russell in terms of the ber and bei functions.

The author next considers the problem of the circuit formed by two parallel cylindrical conductors and solves it by a similar method. The solution is given in terms of series which are convergent in most practical cases. In a few cases where we have large wires very close together and the frequency is abnormally high, the solutions cannot be used since the series become divergent. A table of the limiting frequencies at which the formulæ will hold is given. The formulæ are tested by applying them to calculate the experimental results found by Kennelly and by

C. N. Hickman and [Miss] C. M. Sparks of the Bureau of Standards. The following are some of the results found. $R$ = a.c. resistance, $R_0$ = d.c. resistance. Diameter of wires, 0·651 cm. Length of circuit, 1716·3 cm.

| Distance between Wires in cm. | Frequency. | $R/R_0$ measured. | $R/R_0$ computed. |
|---|---|---|---|
| 0·039 | 3000 | 2·403 | 2·390 |
| 0·175 | 3000 | 2·111 | 2·114 |
| 0·67 | 3000 | 1·789 | 1·792 |
| 1·30 | 3000 | 1·705 | 1·692 |
| 5·15 | 3000 | 1·619 | 1·618 |

| Distance between Wires in cm. | Frequency. | Measured Inductance, Microhenrys. | Computed Inductance, Microhenrys. |
|---|---|---|---|
| 0·039 | 3000 | 5·18 | 5·29 |
| 0·175 | 3000 | 6·86 | 6·86 |
| 0·67 | 3000 | 10·52 | 10·55 |
| 1·30 | 3000 | 13·27 | 13·39 |
| 5·15 | 3000 | 20·89 | 20·99 |

A. R.

**307**. *The Condenser Machine, a New Electrostatic Generator of High-Tension Current.* **H. Wommelsdorf.** (Elekt. Zeits. 41. pp. 726–727, Sept. 16, 1920. Ann. d. Physik, 63. 3. pp. 295–300, Oct. 7, 1920).—A new form of the author's electrostatic machine is described, with certain modifications which were devised to increase its usefulness for demonstration purposes, but also improve its suitability for technical applications. The machine has been made so as to be more easily mounted and demounted, the simplicity of its working is increased, and the device of embedding the sectors in the mass of the insulating discs has raised the efficiency and the output of the machine. The most important advantage of the condenser machine is the circumstance that it produces currents at a potential of 100,000 to 250,000 volts. With the new form of machine described the greatest attainable length of spark is 35 cm., which is approximately double that of the earlier Holtz and Wimshurst influence machines. The current in the larger machines varies from about 1·3 to 4 milliamps. J. J. S.

**308**. *Voltmeter-Amplifier.* **H. Abraham, E. Bloch,** and **L. Bloch.** (Soc. Franç. Elect., Bull. 10. pp. 9–24, Jan., 1920. J. de Physique et le Radium, 1. pp. 44–57, Aug., 1920.)—The first part of this paper gives a *résumé* of the properties of three-electrode valves, and the second part describes the construction and use of an amplifying voltmeter which is capable of measuring directly alternating voltages less than one ten-thousandth of a volt at all frequencies. This apparatus has already been described elsewhere [Abs. 878B (1919)]. The voltage to be measured is applied on the input side of an amplifier of 1, 2, or 3 stages, and from the readings of a milliammeter in the anode circuit of the last valve the value of the applied voltage can be obtained by use of the calibration curve of the apparatus. A number of examples are given of the use of the instrument for various purposes. A. W.

**309.** *The Shadow Electroscope : Construction and Applications.* **R. Whiddington.** (Cambridge Phil. Soc., Proc. 20. pp. 109–115, Sept., 1920.)—The instrument described is a simple electrostatic voltmeter of the gold-leaf type, designed primarily for class instruction, and while not capable of the highest precision is yet sufficiently accurate for many purposes. It consists essentially of an ordinary gold-leaf electroscope, one side of which is fitted with a semi-transparent voltage-scale on which a sharp shadow of the leaf is cast by means of a 2-volt lamp, the filament of which is arranged parallel to the leaf. To obtain an even voltage scale and constant capacity over the working range, the metal box containing the leaf system was made of quadrant shape. A small lime-coated spiral is fitted inside the electroscope, this spiral when heated providing a controlled source of ions for experiments on ionisation. The position of this spiral was such that there was no possibility of convection currents disturbing the leaf. The voltage-range of the instrument is from 100 to 500 volts, and with a good leaf it is possible to estimate to 1 volt, an accuracy sufficient for most purposes.

Examples are given in which the electroscope is employed in the measurement of voltages, small capacities, and specific inductive capacities. A. B. W.

## ALTERNATING CURRENTS AND MAGNETISM.

**310.** *Magnetic Properties of Non-homogeneous Materials ; Magnetic Analysis by Inspection of Hysteresis Curve.* **E. Gumlich.** (Archiv f. Elektrot. 9. pp. 153–166, Aug. 8, 1920. From the Physikal.-Techn. Reichsanstalt.)—The effect of inhomogeneity of the test piece, on magnetisation curves taken by the ballistic or magnetometer methods, is determined partly by calculation and partly by experiment. When the material is made up of alternate strips of steel and soft iron, wavy hysteresis curves are obtained. With increasing content of hard material, a fall in the max. induction is accompanied by a bulging out of the ascending curve for values of H between 40 and 60 gauss. With 70 % hard material, the bulge has already reached the H-axis, but the greatest part of the descending branch between remanence and coercive force still bears the character of the soft material. On adding soft material to steel, an effect is visible in the descending branch of the hysteresis curve ; whilst there is little change at first in the remanence, a bay develops on the curve between remanence and coercive force, and even with 50 % hard material there is a very low coercive force. This is due to the opposite directions of the flux in the two constituents. Curves of $\mu$ and B are given for the two series of composite specimens. These show two maxima of $\mu$ for steel with added soft-iron up to 30 %. The form of the curve enables a magnetic analysis to be made with fair approach to accuracy. As an example, a steel wire containing 5 % tungsten and hardened at 950° C. gave two maxima of $\mu$ for H values 6 and 37 respectively. Employing the empirical rule that $\mu_{\text{max.}}$ occurs at a field intensity which is 1·3 times the coercive force, the values of the coercive force thus found were 4·6 for the soft material and 28·4 for the hard ; the measured value of the latter was 27·5. Other examples cited are cases of Al and Mn alloys. G. E. A.

V.2
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**311.** *Magnetic Permeability of Iron and Nickel for Hertzian Oscillations.* **R. G. Loyarte.** (Univ. de La Plata, Publ. [ser. mat.-fis. No. 29], 1, 9. pp. 453–498, March, 1917.)—The knowledge of the relation between the magnetic permeability and the frequency of the electric oscillations to which a magnetic material is subjected, is of technical importance as showing whether or not these substances are able to follow exceedingly rapid changes of field. From the physical standpoint its importance arises from the fact that it strengthens our knowledge of the molecular structure of the elementary molecular magnets, concerning which it is desirable that there should be known the moment of inertia, the natural oscillation frequency, and the logarithmic decrement. Up to the present there has been available no series of measures which would make clear the relation between these quantities, since all previous observers have restricted themselves to a few points on the curve in question, and each one worked over a restricted range, while they have in general not fulfilled the indispensable conditions necessary, namely: use of nearly undamped oscillations; use of very weak magnetic field in order to work in the reversible region and avoid hysteresis; avoidance of eddy currents. The authors then discuss theoretically this relation, first for the case where the weakening of the elementary magnet is due to radiation, and secondly for the case where it is due to mechanical vibration; curves being given in illustration of the two cases.

The author's measurements complied with the conditions mentioned above, and the method adopted for the three highest frequencies was to deduce the log. decrement, $\delta$, of the oscillations which are set up on two parallel wires of radius $a$ placed $d$ cm. apart, from the formula: $\delta = \left\{1 \div 4a \log_e (d/a)\right\}(\mu/n\sigma)^{1/2}$, where $n$ is the number of oscillations per sec., and $\sigma$ the conductivity of the material of the wire.

By measuring $\delta$, $n$, $\sigma$, $d$, and $a$, $\mu$ can be calculated.

For these short waves a Lecher system was used, excited by a Rukop oscillator; for the longer ones a Wien impact excitation system was employed. In the latter case, if W′ and L′ be the resistance and self-inductance of the circuit for the frequency considered, $\delta = W'/2L'$. Since also $W' = (1/a)(\mu n/\sigma)^{1/2}$ it is clear that knowing L′, $\delta$, $a$, $n$, and $\sigma$, $\mu$ can be calculated. The chief results are given below:—

| $n$ = Frequency. | Nickel. | | Iron. | |
|---|---|---|---|---|
| | $\mu$. | $\delta$. | $\mu$. | $\delta$. |
| 0 | 13 | — | 158 | — |
| $3 \cdot 75 \times 10^6$ | 15·3 | 0·27 | 114 | 0·73 |
| $5 \cdot 4 \times 10^6$ | 13·6 | 0·21 | 114 | 0·61 |
| $6 \cdot 33 \times 10^6$ | 14·7 | 0·20 | 122 | 0·60 |
| $7 \cdot 48 \times 10^6$ | 15·8 | 0·196 | 122 | 0·56 |
| $3 \times 10^8$ | 14·6 | 0·245 | 58·4 | 0·106 |
| $4 \cdot 95 \times 10^8$ | 18 | 0·210 | 42·2 | 0·070 |
| $9 \cdot 52 \times 10^8$ | 16·8 | 0·145 | — | — |

It will be seen that in the case of Ni the apparent permeability increases and then remains constant, and does not diminish as the results of Arkadiev appear to show. [See next Abs.] L. H. W.

**312.** *Constants of the Elementary Magnets of Nickel and Iron.* **R. G. Loyarte.** (Univ. de La Plata, Publ. [ser. mat.-fis. No. 32], 2. pp. 105-135, Dec., 1917.)—In an earlier paper [see preceding Abs.] the authors have shown that for very rapid oscillations the permeability, properly so-called, is imaginary, the real part being the true permeability and the imaginary part the "magnetic conductivity." The first is called $\mu$ and the second is designated $\sigma_m$. What is measured in the case of very rapid oscillations is a combination of $\mu$ and $\sigma_m$, and this is termed by the authors the apparent permeability "$\mu$." If $n$ be the frequency of the external force, then

$$``\mu" = \mu[(1 + 4\sigma_m^2/\mu^2 n^2)^{1/2} + 2\sigma_m/\mu n].$$

*Permeability of Nickel for Rapid Oscillations.*—The value of $\mu$ was determined for a large number of different rapid frequencies and the existence of the magnetic conductivity $\sigma_m$ was confirmed, the following constants of the elementary magnet being obtained :—

| | Nickel. | Platinum. | Mercury. |
|---|---|---|---|
| Moment of inertia, I.... | $3 \cdot 47 \times 10^{-38}$ | $1 \cdot 69 \times 10^{-39}$ | — |
| Natural frequency, $n_0$ .. | $1 \cdot 042 \times 10^{11}$ | $1 \cdot 03 \times 10^{12}$ | — |
| Log. decrement, $\delta$ ..... | $0 \cdot 5 \times 10^{10}$ | — | — |
| Diameter, $d$, in mm. ... | $0 \cdot 62 \times 10^{-6}$ | — | $0 \cdot 28 \times 10^{-6}$ |
| Molecular field, A ..... | $3 \times 10^{6}$ | $3 \cdot 1 \times 10^{6}$ | — |
| Observer ............ | Loyarte | Gans | Perrin |

These values for Ni are contrasted with those for Pt and Hg, obtained by Gans and by Perrin respectively.

The natural oscillations are, as can be seen, very little damped, so that if Ni be magnetically excited, the molecular magnets undergo a large number of oscillations before taking up a definite position, *i.e.*, before the magnetisation is that corresponding to the field produced. But all this takes place in a minute fraction of a second, since the amplitude of the angle, $\theta$, formed by the elementary magnet with the direction is proportional to $e^{-\delta t/IT}$, whence $\delta = 0 \cdot 025$ and $T = 10^{-11}$ approximately.

*Permeability of Iron at very High Frequencies.*—For iron the results obtained with waves of length 21·2 cm., give a value of $\mu$ too large compared with those obtained with longer waves (60 cm. to 1 m.), so that the authors' measurements will not fit any theoretical curve of $\mu$. The authors therefore propose to carry out new measurements with waves shorter than 20 cm. and also between 5 and 10 m., since it is possible that there exists more than one natural oscillation frequency. For these reasons they have been unable to calculate the constants for iron.

L. H. W.

**313.** *Double Solenoid for the Production of Uniform Magnetic Fields.* **S. J. Barnett.** (Phil. Mag. 40. pp. 519-520, Oct., 1920.)—All the advantages of precise winding may be obtained, and at the same time the (small) effect of spirality on the uniformity of the field may be largely eliminated, and the trouble due to long leads avoided in the following way. Two solenoids are constructed with the same pitch and number of layers, and with practically the same length, but with somewhat different diameters, so that one will slide inside the other. One coil is wound in left-handed spirals, the other in right-handed spirals, and the two are mounted coaxially and concentrically. The construction necessitates that the successive layers in each solenoid start from points 180° apart. When each coil has two or more layers it is probably best to wind all layers of one coil with the same integral number of turns, and all layers of the other coil with this same number plus or minus one half-turn. It is then possible to join successive layers of the two solenoids systematically by very short connectors at the ends, in such a way that the current goes alternately up a layer of one solenoid and down a layer of the other, and that the small effects of each pair of short connectors are practically cancelled near the centre of the field. Difficulties are encountered in making the windings precise close to the ends, but slight irregularities there are unimportant. A. W.

**314.** *Saturation Value of Magnetisation of Cementite.* **S. Saitô.** (Tôhoku Univ., Sci. Reports, 9. pp. 319–322, Aug., 1920. Forty-first report from the Iron and Steel Research Inst.)—The cementite was electrolytically isolated from a steel containing 1·58 % of carbon, and pressed into cylindrical form, 1·36 cm. long and 8 mm. thick. The specimen, which had a density 4·35, was placed between the poles of a Du Bois electromagnet, and its intensity of magnetisation in strong fields was determined by the ballistic method. The magnetising field was measured by means of an annular coil which passed round the cementite. A graph is given which shows an increase of specific magnetisation with field from 125 in a field of 6000 to its saturation value 135 in a field of about 13,000 gauss. The specific magnetisation of a cylinder of white cast-iron containing 3·75 % carbon was also measured, and the data employed to calculate that for cementite. The value found agreed with the experimental value. Two double carbides of iron and tungsten ($4Fe_3C . WC$) and a double carbide of iron and chromium ($18Fe_3C . Cr_4C$) were next tested, the value 80 being found; the carbides were not very pure. Finally a number of steels with varying carbon content were tested at room temperature and also at a temperature a little above the $A_0$ transformation of cementite. It was found that a higher magnetising field was required for saturation in proportion as the carbon content is increased, showing that the cementite is magnetically harder than the ferrite. G. E. A.

**315.** *Method of Measuring Magnetic Hardness of Ferrous Metals.* **L. W. Wild.** (Faraday Soc., Trans. 15. pp. 1–12; Disc., 13–15, June, 1920. Electrician, 84. pp. 320–322, March 19, 1920. Abstract.)—The magnetic hardness of iron or steel is defined as the coercive force of the material after having been magnetised to saturation. The specimen is a rod of diameter ½ in. and length 3 in. This is placed within a magnetising coil of the same length, and the whole fitted within a yoke in the form of a hollow square. A current of about 20 amps. is passed through the coil for an instant and the specimen is magnetised to saturation. The yoke is then removed, and the demagnetising effect of the poles takes away much of the remanent magnetism. What is still left is measured by the ballistic method which may be contrived so that the galvanometer reads directly in terms of coercive force. The coil on the test bar should not exceed 1 in. in diam. and ½ in. in length. The method of calculation employs Ascoli's graphical construction, and Thompson's values of the demagnetising coefficients are used [see Abs. 469B (1913)]. The method is then applied to a series of bars of iron and mild steel, after these have undergone the heat treatment of normalising, annealing, maturing, tempering, and refining. A series of seven steels is next tested, and their behaviour is discussed in relation to their chemical composition. For details the paper should be consulted. In the *discussion*, exception was taken to the author's definitions of the methods of treatment as being different from the generally accepted ones. The magnetic critical temperature method of calibrating the thermo-couple employed was also commented upon. G. E. A.

**316.** *The Experiments of Theodorides and Kopp and the Magneton.* **P. Weiss.** (Arch. des Sciences, 2. pp. 417–418, Sept.–Oct., 1920. Paper read before the Soc. Suisse de Physique.)—Honda and his collaborators concluded from their research on solid salts that the calculated atomic moments were not in agreement with the theory of the magneton, whilst Cabrera came to the opposite conclusion. Theodorides has tested a number of salts and finds that the linear variation of the reciprocal of the coefficient of magnetisation with temperature is verified with great exactness as required by the theory of the molecular field. His results are therefore in accord with the theory of the magneton. When the atomic moment is feeble, the diamagnetism underlying the atom is no longer negligible, and has to be taken into account if the linear law is to be maintained. Kopp has separated the paramagnetism from the diamagnetism in the same atom and has determined each of these, finding for Pt 7·93 magnetons and for Pd 8·03 magnetons, their coefficients of diamagnetic magnetisation being $-0{\cdot}14 \times 10^{-6}$ and $-0{\cdot}54 \times 10^{-6}$ respectively. It is inferred that if Pt has 8 magnetons for the temperature-range 15° to 400°, this metal contains exactly 9 magnetons for the range 640° to 1000°. G. E. A.

**317.** *Molecular and Cosmical Magnetism.* **S. Chapman.** (Nature, 106. pp. 407–408, Nov. 25, 1920.)—The theory which regards the magneton as an anchor ring of negative electricity in rotation about an axis of symmetry, will explain the direction of the general magnetic fields of the earth and sun as due to their rotation. S. J. Barnett has shown experimentally that ferromagnetic bodies in rapid rotation become magnetised and has given a theoretical explanation of the magnitude of the effect observed. This theory, however, will not suffice to explain the magnitude of the solar and terrestrial magnetic effects. The author has developed a theory according to which para- and dia-magnetic as well as ferromagnetic substances should be magnetised by rotation. When the constraints on the magneton are elastic the intensity is proportional to the angular velocity, but the factor of proportionality varies with the nature of the constraint. At high temperatures an upper limit of magnetisation will be reached, which can be calculated on certain assumptions. A correct estimate of the fields of the earth and sun is then possible. The theory may be applied satisfactorily to sun-spots. Additional hypotheses would be necessary to account for the obliquity of the magnetic axes of the earth. If the obliquity be assumed, secular variations of the solar and terrestrial magnetic fields may be explained by a precessional motion of the magnetons. L. L.

## RADIOGRAPHY AND ELECTROPHYSIOLOGY.

**318.** *Investigations upon the Current Form of High-Tension Intermittent and Pulsating Currents.* **F. Voltz.** (Archiv f. Elektrot. 9. pp. 247–278, Oct. 10, 1920.)—The usual apparatus for exciting X-ray tubes is described and the general form of the current impulse illustrated; the practical importance of the current form is then discussed. To investigate the current form, the Braun tube or the Joubert disc may be used; the former is, however, hardly applicable with the high tension employed, which also causes interference with the galvanometer or electrometer of the latter. The author adopted the Lessing-Gehrke tube which is essentially a rapidly rotated Geissler tube. The apparatus employed is illustrated and described in detail. Results obtained by photographic means and diagrams derived from these are illustrated and discussed for intermittent current obtained by use of an induction coil, when this is unloaded or loaded by means of Lilienfeld X-ray tubes of various types. These results are compared with theoretical values calculated by knowledge of the physical constants of the circuit.

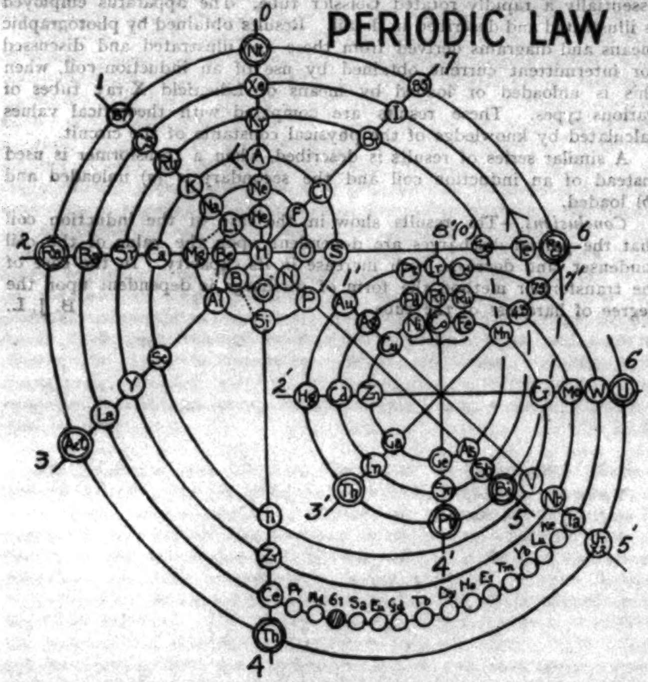
A similar series of results is described, when a transformer is used instead of an induction coil and the secondary is (*a*) unloaded and (*b*) loaded.

*Conclusions.*—The results show in the case of the induction coil that the partial discharges are dependent upon the value of the coil condenser, and decrease with increase in its capacity. In the case of the transformer method the form of discharge is dependent upon the degree of hardness of the tube. B. J. L.

## CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

**319.** *Periodic Classification of the Elements.* **C. R. Nodder.** (Chem News, 121. p. 269, Dec. 3, 1920).—The author presents a diagrammatic arrangement of the elements which is based on the 3-dimensional spiral arrangement proposed by Harkins. The present proposal illustrates the periodic classification without recourse to the 3-dimensional arrangement.

*Two-Dimensional Spiral Arrangement.* **J. R. Partington.** (*ibid.*, p. 304, Dec. 24, 1920.) The 2-dimensional spiral form indicated above should prove distinctly useful as a wall-chart for teaching purposes. Corresponding radii of the primary and secondary spirals are parallel to one another and are similarly numbered. The double circles (those showing Bi, Pb, Th) are intended to indicate pleiads of isotopes. A. B. W.



**320.** *The Origin of the Elements; Laws of Atomic Weights.* **J. H. Vincent.** (Phys. Soc., Proc. 32. pp. 271–289; Disc., 289–290, Aug., 1920.)—The atomic weights are regarded as the weighted mean values of the atomic weights of the isotopes of the elements; but it is assumed that, as a rule, the atomic weight is near that of some one isotope. Figures and tables are drawn up showing how this accounts for the values of a large number of atomic weights, if we also assume that the weights and positions in the periodic table of any isotope are conditioned by laws similar to those holding in the recognised radio-active families. The elements are all supposed to be derived from parent elements by processes known to occur in actively radiating families; but their radio-activity is not in general detectable by the usual means, owing to the velocity of expulsion of the particles being low.

The possibility of the reversibility of some radio-active processes is regarded favourably. The various difficulties in connection with the views advocated are discussed, and some suggestions for experiments are made. Finally, the theory is used to explain the so-called laws of the atomic weights of elements of low atomic weight, and the shape of the curve obtained when the atomic weights are plotted against Moseley's numbers. AUTHOR.

**321.** *Molecular Forces of Liquid Crystals.* **O. Lehmann.** (Zeits. f. Physik, 2. 2. pp. 127–145, 1920.)—Liquid crystals are, like solid crystals, capable of growing, and are thus phases in the thermodynamic sense; amorphous and colloidal bodies, on the other hand, are not, even if they show accidental double refraction. Their molecules endeavour, so far as is possible, to lie parallel to one another; but even in the case of solid crystals, this does not occur when these are continuously distorted or twisted. The author therefore maintains that no fundamental difference exists between the two, and hence there is no ground for rejecting the term "liquid crystal." The detailed behaviour of these "crystals" is illustrated. [See also Abs. 1124 (1919).] L. H. W.

**322.** *Theory of Invar.* **K. Honda** and **H. Takagi.** (Faraday Soc., Trans. 15. pp. 54–61, June, 1920.)—It has been considered that invar represents a definite compound of iron and nickel, but the authors show that many other alloys of these metals exhibit regions of zero thermal coefficient of expansion at various temperatures. The particular alloy, invar, happens to have this region at room temperature, and it would be possible, by the addition of small quantities of other elements, to bring this point of minimum coefficient either slightly above or slightly below room temperature, so that the coefficient of expansion would have a very small negative or positive value at room temperature.

J. W. T. W.

**323.** *Intercrystalline Fracture in Mild Steel.* **W. Rosenhain** and **D. Hanson.** (Iron and Steel Inst., J. 102. pp. 23–30; Disc. and Corres. 31–37, 1920. Engineering, 110. pp. 421–422, Sept. 24, 1920.)—Four cases of intercrystalline fracture in mild steel are discussed. In the case of a steel wrapper plate for the combustion chamber of a marine boiler the explanation was found in the manner in which the carbide of iron existed as films around the crystals of ferrite. The same structure was found in a half-inch mild-steel plate from the drum of a water-tube boiler. In both these cases a difference in property could be detected between the surface and central portions of the metals. In the latter case the crack had started from the rivet holes. Although intercrystalline failure had resulted in a steel plate from a high-pressure boiler, tests carried out on the plate even with slow loading produced a fracture which passed through the crystals, and it is suggested that stresses must operate for years to cause intercrystalline failure. The failure of a mild-steel tube, practically unstressed, from a nitre bath at 300° C. was traced to its cold-worked condition. A similar tube which had been annealed did not crack. F. C. T.

**324.** *Theoretical Study of the Equilibrium Diagrams of Binary Alloys.* **J. Galibourg.** (Rev. de Mét. 17. pp. 630–634, Sept., 1920.)—The study of the equilibrium diagrams of binary alloys has resulted in the formulation of a series of rules, certain of which are the consequences of thermodynamic laws. Knowledge of the latter is indispensable for tracing and interpreting the experimental diagrams. In particular it is assumed that two branches of the liquidus separated by an angular point correspond to the deposition of two different solid phases. This proposition is almost intuitive when regarded from the standpoint of continuity, but the author here attempts its demonstration. He only considers the case where the two branches of the liquidus are situated on either side of the horizontal of the angular point, since the opposite case corresponds to the presence at the angular point of a eutectic, with deposition of two distinct phases to the left and to the right of this point. Transition from one phase domain to another should be marked by discontinuity in one of the properties of the alloy in the neighbourhood of the transition point. The above proposition will be demonstrated, therefore, by establishing a discontinuity in one of the physical magnitudes which define the state of the alloy when one of the equilibrium factors, such as temperature, is made to vary in a continuous manner. It is then shown in the paper that where no angular point occurs there is no change of phase, while at an angular point phase-change takes place. An appendix considers more fully the theoretical exposition of the main paper, nine diagrams of special cases being included. H. H. Ho.

**325.** *The Equilibrium Diagram of Carbon-Manganese Alloys.* **K. Kido.** (Tôhoku Univ., Sci. Reports, 9. pp. 305–310, Aug., 1920. 39th report of the Iron and Steel Research Inst.)—Gives the results of experimental work carried out to complete the equilibrium diagram of carbon-manganese alloys formerly published by Stadeler [Abs. 1326 (1908)]. The earlier work showed that Mn and its carbide, $Mn_3C$, form in the liquid state a continuous series of solid solutions from pure Mn to the alloy containing 6·75 % C. The present results show that Mn and its carbide are only partially soluble in each other in the solid state, and as the temperature decreases the solubility of both decrease, until at 920° they form a eutectoid, containing about 3·6 % C. C. O. B.

**326.** *Density, Specific Volume, Hardness, and Carbon Percentage of Steel.* **M. Levin** and **K. Dornhecker.** (Ferrum, 11. pp. 321–329, Sept. 8, 1914.)—Experiments were made with electrolytic iron, total impurity 0·01 % ; with 13 steel rods from Krupp, total impurity ranging from 0·182 to 0·329 %, carbon increasing from 0·11 to 1·54 %, Si from 0·01 to 0·12 % ; and further with six other specimens of Swedish iron ranging in carbon from 1·97 to 3·75 %. The density of the electrolytic iron was increased by heating the specimens for 2 hours in a vacuum up to 1000° C., to 7·875 max. In the carbon steels this heating caused no change when the carbon was below 1 %, no oxidation or loss of carbon being observed; in higher carbon steels the density decreased the more the C percentage increased. When the heating was continued for 160 hours, the loss in density, from 7·8 to 7·5, *e.g.*, was rapid during the first hours and very slow afterwards. This agrees with observations of Wüst and Geiger that temper-carbon is segregated also from relatively pure iron, and that the segregation takes place rather suddenly and is scarcely increased by subsequent heating. For the Brinell hardness tests the specimens were heated to 650°. The hardness was found to increase with the C content, from 99 to 316·6 in the case of the Krupp steels, and from 289 to 494·5 in the case of the others. The curve Hardness/Carbon percentage was quite regular, and did not show any of the characteristic points observed by Walberg and others. H. B

**327.** *Crystalline Nature of Graphite and Temper-Carbon obtained from Cast Iron.* **K. Iokibé.** (Tôhoku Univ., Sci. Reports, 9. pp. 275–279, Aug., 1920. 37th report of the Iron and Steel Research Inst.)—Describes the examination, by means of X-ray analysis, of samples of graphite and of temper-carbon obtained from grey cast iron and annealed white iron respectively. The separated samples of carbon were compressed and examined by X-rays, photographs being taken of the diffraction figures produced by the action of X-rays on minute crystals, whose orientations are uniformly distributed in all directions. By comparison of the photographs secured with one obtained from natural graphite, it is concluded that the so-called graphitic carbon and the temper-carbon as found in cast iron are both the same substance as natural graphite, and temper-carbon should hence not be considered as amorphous. [See Abs. 784 and 1140 (1917).] C. O. B.

**328.** *On the Equation for the Chemical Equilibrium of Homogeneous Mixtures.* **A. W. Porter.** (Faraday Soc., Trans. 15. pp. 75–82, June, 1920.)—This paper embodies Part I of the subject, and deals with equilibrium at constant temperature. The equation determining the equilibrium quantities of the components of reacting mixtures has been fully worked out by many methods in the special cases in which all the reactants are perfect gases. When the mixture is not a mixture of perfect gases the difficulties of the problem become very great, and no very explicit solution seems to have been given, though the whole matter is implicitly contained in Willard Gibbs' method of the chemical potential. It is very desirable that a solution should be found in terms of quantities which are more directly ascertainable experimentally. Such a solution can be expressed in terms of osmotic pressures, the meaning of which is easily grasped even though very great difficulties still exist in connection with the mechanism by which the osmotic pressure is brought about in strong solutions. The first difficulty arises from the fact that the additive law breaks down, and the method now described in detail for consistent results is that which led the author to find exact equations for osmotic pressures in terms of vapour pressures [see Abs. 356 (1908)]. It is identical in principle, with the method of maximum work recently advocated by McC. Lewis. An equation is derived which is exact whether the mixture consists of gases or liquids, or a homogeneous mixture of both, and holds good not merely for the limiting values of the variables, but for all intermediate values. A general equilibrium equation at constant temperature is next derived, and applications are given for the following four characteristic cases: When the separated components are all incompressible liquids; all perfect gases; the simplest departure from the law of perfect gases; Van der Waals' fluids. In none of these cases, except that of the perfect gas, is the equilibrium expressed in terms of the actual concentrations in the mixture. Unfortunately, to make this further step, a knowledge of the connection between osmotic pressures and concentrations is required, and this is only known at present for very few substances. Thermodynamics does not give any theoretical value for the connection, and a further development of the kinetic theory is necessary for its general evaluation. These examples serve to emphasise the inherent difficulties which present themselves with deviation from the law of perfect gases. H. H. Ho.

**329.** *Quantum Theoretical Significance of the Velocity Constants.* **M. Trautz.** (Zeits. f. Physik, 2. 2. pp. 117–126, 1920.)—Every velocity constant consists of two different factors: one which expresses the number of possibilities for the reaction, and a second which indicates the particular possibility to be realised. The latter may be termed the activity or yield factor; the former is the impact or oscillation number. The present paper is concerned principally with this impact number; and Section 1 deals with the quantum theoretical importance of the impact constant. Section 2 investigates an assumption as to the thermal content of the reaction mixture, and derives the temperature coefficient of the reaction velocity. By comparison of the theoretical gas and quantum expressions in the region of their validity, the independent temperature factor in the velocity constant is given to the first order as $k_I = k/h$, and to the second order $k_{II} = k/h \cdot (e^{-i_1 - i_2 - i_{1,2}})$, where $k$ and $h$ are the well-known constants in the radiation theory, and the $i$'s the Nernst constant ($i_1$ and $i_2$ for the separate molecules, and $i_{1,2}$ for the addition product). The importance of Planck's quantum $h$ is now apparent, while the $i$ values are obtained empirically. The general temperature function is found to be, $T \cdot e^{-q_0/RT - \int_0^T dT/RT^2 \int_0^T (c_i - c_a) dT}$, where $q_0$ is the thermal activity at $T = 0$, $c_a$ the molar heat of the reaction mixture (*i.e.*, of active molecules), $c_i$ the sum of the molar heats of the inactive parts. Another temperature function has not been assumed. $q_0$ may be calculated from the red spectral limits of absorption of the reaction considered from $q_0 = Ah\nu$, where A is the Loschmidt number and $\nu$ the particular frequency. Agreement between experiment and this formula has been found to be as good as, and, in part, better than between experiment and previous expressions. The terms for the reaction velocity, as earlier for the case of equilibrium, are now brought completely into thermodynamical quantum theoretical form, and at the same time entirely in unison with previous observational data. H. H. Ho.

**330.** *Studies on Solubility.* I. *Solubility of Salts in Salt Solutions.* **J. N. Brônsted.** (Am. Chem. Soc., J. 42. pp. 761–786, April, 1920.)—New equations are given to express the influence of one salt upon the solubility of another. The fundamental equations are simplified by assuming that "the activity coefficient of a mixed salt solution to the same for any ion of the same type." The essential features of the equations are that no assumptions are made as to the degree of dissociation of the solutions, so that the results could be interpreted equally on the hypothesis of complete dissociation. The equations have been tested, especially on coordinated cobaltic salts, with satisfactory results. A table is also given showing the calculated influence of a solute on the dissociation constant of pure water, which is approximately doubled in decinormal solutions. T. M. L.

**331.** *The Photochemical Oxidation of Hydriodic Acid.* **C. Winther.** (Kgl. Danske Videnskabernes Selskab. 2. No. 2. pp. 1–28, 1920.)—A critical examination of Plotnikow's researches of 1908. Plotnikow exposed solutions of KI to the rays of a uviol lamp, added diluted sulphuric acid containing oxygen to the solution, and determined the diminution of the oxygen concentration without stirring; he found that the velocity constant was proportional to the light intensity, that there was no induction period, that the process was more sensitive to blue than to ultra-violet rays, and that the addition of carbide to the solution and the use of the latter as light-filter did not affect the reactive velocity. Experimenting together with H. Poulsen and V. A. Larsen, and making use of his quartz-mercury lamp and fluorimeter [Abs. 59 (1914) and 227B (1915)], the author questions most of these statements. Hydrochloric acid is used, stirring applied, and the oxygen concentration is kept constant, contrary to Plotnikow. It is found that the reaction velocity depends upon the formation of the tri-iodine ions $\overline{I_3}$, which ion has two absorption bands near 350 and 290 $\mu\mu$. This optical auto-sensitiser is formed by the very process it is to accelerate (similarly in the oxidation of leuco-compounds, of alkaline pyrogallic acid, and sodium sulphite), and the process must possess a measurable velocity in the darkness; the rate of the oxidation is first zero and increases during an induction period to a constant value. The sensitiveness of the oxidation is, both for the same wave-length and different ion contractions, and for different wave-lengths, proportional to the absorption of the tri-iodine ion. H. B.

**332.** *The Photochemical Efficiency of the Absorbed Radiation.* **C. Winther.** (Kgl. Danske Videnskabernes Selskab. 2. No. 3. pp. 1–35, 1920.)—The primary photochemical process consists in an absorption of radiation energy and an augmentation of the chemical potential of the substance; this process is followed by the voluntary secondary darkness-processes occurring with loss of free energy. The two processes being independent of one another, the secondary loss may be greater or smaller than the primary augmentation of energy; in the first case the total light-process is irreversible, in the second reversible, but there is no difference between the two groups with regard to the photochemical process. The effect of the exposure is not at all dependent upon the magnitude and the direction of the affinity in the total light process. According to Einstein's photochemical law of equivalence, each absorbed quantum should split off one electron. But the experiments of Warburg, the author, and others show that this law does not hold as a rule, and it cannot even be asserted that the quantum $h\nu$ corresponds to the moving of an electron from one stationary state to another. Yet there is a quantitative relation. The molecules of a substance are, at the same time, not all in the same condition of activation, and there is (Marcelin) a difference between the relative critical energy and the mean energy of the molecules. The energy of absorption necessary for the oxidation of hydriodic acid, *e.g.*, is found to agree with the energy required for the activation. On this basis it is intelligible how the specific photochemical effect is of the same order of magnitude for a series of very different processes (Warburg), and the law of critical efficiency renders it possible in many cases to calculate the light-sensitiveness of a process, if its darkness temperature-coefficient be known. These coefficients are generally very small, as they ought to be, and they increase sometimes with the wave-length. The law of critical efficiency also elucidates the possibility of chemiluminescence. The deviations from this law are to be explained by errors of observation, by insufficient stirring, the formation of light catalysts, and by the observation that, in the cases of zinc oxide [particulars to be published] and of hydriodic acid, the absorbed radiation is quantitatively transformed into radiation of a far shorter wave-length, this latter radiation being absorbed not only by the substance transformed, but also by other substances. H. B.

**333.** *Energy Changes during Photochemical Processes in Gases.* IV. *Influence of Wave-lengths and Pressure on Photochemical Ozonisation; Einstein's Equivalent Law.* **E. Warburg.** (Preuss, Akad. Wiss. Berlin, Ber. 34. pp. 872–885, 1914.)—When radiation energy of wave-length $\lambda$ is absorbed the primarily decomposed quantity $p$ of the photolyte, expressed in mols per gm. cal. absorbed is, according to Einstein, $p = \lambda/1{\cdot}98c$, where $c = 14{,}300$. In ozonisation the primary reaction is $O_2 = O + O$, the secondary $O_2 + O = O_3$, and also re-formation of $O_2$ from $O + O$. The specific photochemical effect $\phi$ indicates the amount of end product obtained, and if the second secondary reaction $O + O = O_2$ be excluded, $\phi$ should be $= 2p$. With oxygen pressures of 100 to 160 kg/cm.$^2$ and $\lambda = 0{\cdot}209$ $\phi$ was found to be $1{\cdot}35 \times 10^{-5}$, while $2p = 1{\cdot}47 \times 10^{-5}$ [see Abs. 1046 and 1689 (1912) and 1557 (1913)], so that Einstein's law seemed to be fulfilled. For further tests at pressures up to 400 kg./cm.$^2$ a steel cell closed by 2 quartz windows, 10 mm. thick, was constructed, and the Pt capillary (which was easily blocked) for the escaping gas was replaced by a gold tube, 1 mm. internal diameter. For $\lambda = 0{\cdot}253$ the amount of ozone produced was smaller than for $\lambda = 0{\cdot}209$, the amount representing at 125 kg./cm.$^2$ about 55 %, and at 300 kg./cm.$^2$ only 29 % of the theoretical values. This influence of the pressure is not in accord with Einstein's law, which would require modification. It is moreover shown that $p$ should (according to Einstein) increase with increasing $\lambda$ to a maximum, and then suddenly vanish, which is improbable. To account for the discrepancy, it is suggested that not all absorbing molecules need be decomposed. H. B.

**334.** *Electrolytic Sodium Perchlorate from Chlorate.* **J. G. Williams.** (Faraday Soc., Trans. 15. pp. 134–137, June, 1920.)—Working with baths of 250 litres' capacity, the author criticises some statements of Allmand. The efficiency decreases as the bath gets warm, but does not fall off rapidly above 60°; the production per unit energy increases when the temperature is raised; the kg of perchlorate requires 3·4 kw.-hrs. at 41·5° and 3 kw.-hrs. at 59° C. The NaCl content of the bath tends towards an equilibrium depending upon the temperature, being 2·3 gm. NaCl per litre at 31° and 4·7 gm. at 59°. Neutral or acid baths soon turn slightly alkaline by the formation of hypochlorite, unless hydrochloric acid is frequently added; this addition and warm baths are recommended. H. B.